DEPARTMENT OF MINES AND ENERGY

GEOLOGICAL SURVEY

SOUTH AUSTRALIA

REPORT BOOK 96/11

ASSESSMENT OF THE TERTIARY SAND AQUIFER - COUNTY MUSGRAVE PROCLAIMED WELLS AREA, EYRE PENINSULA.

by

John Dowie & Andrew Love
Groundwater Division

APRIL 1996 DME 247/92

CONTENTS PAGE

TABLES

FIGURES — Diagram No.

APPENDIX

DEPARTMENT OF MINES AND ENERGY
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Assessment of the Tertiary Sand Aquifer - County Musgrave, Eyre Peninsula.

John Dowie & Andrew Love

The groundwater resources of the Tertiary sand aquifer in the County Musgrave Proclaimed Wells Area (PWA) have been reviewed in order to assess the potential for its use to augment groundwater currently extracted from the unconfined Quaternary limestone aquifer. The Tertiary sand aquifer is a confined aquifer where it is overlain by the Quaternary limestone aquifer and semi-confined to unconfined in other parts of the County Musgrave PWA. The water quality varies significantly throughout the area, ranging from 500 mg/l to in excess of 35 000 mg/l. Yields range from 1 to 10 ls^{-1} due to the variation in permeability within the Tertiary sand. Results from aquifer tests indicate that transmissivities of the Tertiary sand aquifer vary from 20 to 270 m^{3}/day/m. This report concludes that there is the potential to extract low salinity water, via a network of low yielding wells, from the Tertiary sand aquifer to augment the water supply for Eyre Peninsula. It is important that this is done in conjunction with close monitoring of both the Quaternary and Tertiary aquifers. If the Tertiary sand aquifer was to be considered for use as part of the reticulated supply then further work would be required to fully prove the resource.

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INTRODUCTION

A study of the hydrogeology of the Tertiary sand aquifer in the County Musgrave PWA has been undertaken to supplement the information currently available on the Tertiary sand aquifer and subsequently to assess its potential to augment the water supply in the unconfined Quaternary limestone aquifer.

The water resources of County Musgrave has been the subject of extensive investigations by the Department of Mines and Energy, and the Engineering and Water Supply Department (Painter, 1972; Smith, 1983; Evans,1993; Love et al, 1996). These reports have, however, dealt predominantly with the unconfined Quaternary limestone aquifer with a minor amount of work on the Tertiary sand aquifer.

The Department of Mines and Energy cable tool drilled four wells into the Tertiary sand aquifer in County Musgrave (Figure 1) between December 1994 and January 1995. The Bramfield and Kappawanta groundwater lenses of the Quaternary limestone aquifer were considered to be the most favourable sites for the study, as there are pre-existing bores in the Tertiary aquifer which could be used as observation bores in these two lenses. Therefore two wells were drilled in both the Bramfield and Kappawanta lenses and subsequently geophysically logged and aquifer tested.

Additional information on the Tertiary aquifer obtained from other pump tests is also presented in this report.

HYDROGEOLOGY

Geological Setting

The County Musgrave groundwater resources occur within the tectonically induced Polda Basin. The geology of the area can be summarised as a series of sedimentation periods which extend from the Mid Proterozoic through to the Quaternary overlying an Archaean/Lower Proterozoic metamorphic basement (Cooper and Gatehouse, 1983).

Hydrogeology

An extensive investigation of the groundwater resources of County Musgrave was undertaken in the 1960's and is summarised in a MESA report by Painter (1972).

Painter subdivided groundwater resources in the area into three aquifers of different geological ages (Table 1); an unconfined Quaternary Limestone aquifer which occurs as discrete lenses in the area, a Tertiary sand aquifer which is both confined and unconfined in different parts of the region, and a confined Jurassic aquifer, the existence of which is not well documented.

Jurassic Aquifer

This aquifer occurs predominantly in the east of the Polda Basin. It is ill-defined in the western regions of the basin and due to high salinity (30 000 to 50 000 mg/l) and low transmissivities it is of little hydrogeological significance and therefore will not be elaborated upon in this report.

Tertiary Sand Aquifer - Poelpena Formation

The Tertiary sand aquifer of Polda Basin is a confined to unconfined aquifer of variable quality with transmissivities ranging from very low up to 270 m^3/day/m.

The sands of the Tertiary sequence tend to be unconsolidated, poorly sorted and range from fine to coarse, with varying amounts of silt and clay. Local variations may include a lignitic or pyritic content.

Water quality of the Tertiary aquifer varies regionally. In the vicinity of the Lock coalfield salinity is in the order of 35 000 mg/l to 50 000 mg/l. In the area under investigation salinity is generally below 1500 mg/l. This is presumed to be a result of hydraulic connection with the overlying unconfined aquifer at some time in the past.

The Tertiary clay aquitard is stiff to plastic, with a considerable amount of silt and sand. The content of sand commonly increases with depth, grading into the underlying sand aquifer. Vertical permeabilities determined from core samples range from 4.4×10^{-6} to 1.1×10^{-4} m/day. Recharge to the Tertiary sand aquifer is believed to occur via porous lateral flow and diffuse infiltration from the overlying Quaternary limestone aquifer through the Tertiary clay.

The clay is thin (2-10 metres) but continues throughout the study area.

Quaternary - Bridgewater Formation

The Quaternary deposits consist predominantly of quartz sand, limestone fragments and shell fragments in a calcareous matrix. It varies from uncemented to strongly cemented and covers a large part of the coastal, western Eyre Peninsula. The outcropping surface of the Quaternary limestone is usually characterised as a very well cemented calcrete.

The aquifer is unconfined and water quality ranges from approximately 400 mg/l to over 30000 mg/l. Painter (1972) defined six groundwater lenses in the Quaternary limestone on the basis of a salinity of less than 1000 mg/l.

Recharge to the lenses occurs by direct infiltration of rainfall via surface fractures and sinkholes. Groundwater flow within the aquifer occurs by both porous and karstic flow.

DRILLING AND WELL CONSTRUCTION

The purpose of the drilling program was to provide sites for subsequent aquifer tests. Therefore all four wells were drilled near pre-existing monitoring wells which were completed with 76mm slotted casing and terra firma. It was envisaged that these wells would be used as observation wells during the pump tests.

A cable tool rig was used throughout the entire drilling program. During the drilling casing was driven close behind the bit to ensure that representative water samples could be collected. All the wells, except KPW 81 (5930-1234), were completed with 5 inch (127mm) PVC casing, and a 3 metre long stainless steel Surescreen with a 0.75mm aperture. A summary of drilling is presented in table 2.

Push cores were taken through the clay at TAA 63 (5930-1240) and KPW 81. These were subsequently analysed for vertical permeability tests (table 3).

KPW 81 did not intersect as much Tertiary sand as expected, 1 metre only, and therefore was completed in 76.0mm PVC, slotted from 19-20m, and packed with terra firma.

TAA 63 was drilled by deepening a pre-existing MESA monitoring well, TAA 10. TAA 63, TAA 62 (5930-1235) and KPW 81 were drilled adjacent to a Quaternary limestone well and a Tertiary sand well. KPW 82 (5930-1236) was drilled adjacent a Quaternary limestone well only. Well locations and sketches of each site are provided in figures 2 to 6. A summary of site details is presented in table 4.

Geological logs of the wells are presented in Appendix A.

Field EC (electrical conductivity, uS/cm) measurements were taken for each water sample.

Each well was subsequently geophysically logged with gamma and neutron. These logs are presented in Appendix A.

AQUIFER TESTS

New Well Sites

Aquifer tests at each new well site, with the exception of KPW 81, were conducted as follows:

1. A step test comprising three stages of 100 minutes pumping, followed by period of recovery.

2. Constant discharge test for a period of 24 hours (1440 mins), followed by a period of monitored recovery.

A summary of aquifer test results is presented in table 5, with the aquifer test analyses and associated graphs in appendix B.

An attempt to pump test KPW 81 was unsuccessful due to insufficient water supply through the terra firma completion.

Many of the aquifer tests indicated high well loss. The results could be improved significantly if screens did not have to be pre-ordered for such a remote locality. Nevertheless, considering these logistical problems comparatively good results were obtained.

Existing Monitoring Wells

Short term aquifer tests of 180 minutes duration were also conducted on 8 of the rehabilitated County Musgrave monitoring network wells. Of these only 3 tests were successful, the other 5 bores had insufficient flow to the pump during testing. Results for these 3 tests are presented in table 5. It should be noted that all of the monitoring wells tested are completed with slotted casing and terra firma. This completion method is not suited to aquifer testing and the bores only partially penetrate the Tertiary sand aquifer. It is therefore difficult to calculate accurate aquifer parameters at these sites. It is expected that the actual transmissivities at these three sites would be greater than those calculated. The results provided are therefore not accurate estimates of transmissivity.

Previous Aquifer Tests

The aquifer tests conducted by Painter, 1972, in the Tertiary sand aquifer were reviewed for the purpose of this report. A summary of these results is presented in table 5.

A further aquifer test of the Tertiary aquifer was conducted in the Kappawanta area (5930-1077; fig 2.) in 1991 by this Department. This was a constant discharge test for a period of 1100 minutes. A summary of results is presented in table 5 and the aquifer test analysis is presented in Appendix B.

WATER QUALITY

Drilling

Good quality water was obtained from the Tertiary aquifer in all wells drilled (Table 2). The sample from TAA 63 shows a definite salinity stratification (figure 7). There is a minimal increase in salinity with depth in KPW 82 (figure 8). Only 1 water sample was taken from KPW 81. The aquifer is only 1m thick at this site and therefore salinity stratification is not important. Samples taken during drilling from TAA 62 were later found to be contaminated with water added to the bore for the purpose of drilling.

At each site the water in the above Quaternary limestone was of lower salinity than that of the Tertiary aquifer.

Pumping

Water quality at TAA 63 and TAA 62 improved during the aquifer tests (figs 9-10). This is assumed to be due to leakage from the above unconfined aquifer.

Water quality at the Kappawanta site (KPW 82) remained constant throughout the entire pump test (fig 11). Full analyses for the three aquifer tests are presented in Table 6.

DISCUSSION

There is little, or no head difference existing between the Quaternary limestone aquifer and the Tertiary sand aquifer in the County Musgrave PWA. If the two aquifers are connected there must be substantial connecting fractures between the two systems. There is some support for this in that during aquifer testing, under stressed conditions, leakage to the Tertiary sand aquifer is occurring. It is possible that the leakage is coming from either the Tertiary clay, under its new stressed conditions, or from the Quaternary limestone aquifer, via preferential flow paths. The preferential flow path theory is supported by the observed differences between the vertical permeability from laboratory tests (1.1×10^{-4} to 4.4×10^{-6} m/day - table 3) and leakage calculated from the aquifer tests (2.3×10^{-2} m/day -fig B4) at TAA 63. (This suggests that whilst the aquitard has low matrix permeabilities, it potentially has preferential flow paths within it which increase the vertical flow during pumping by 2 to 4 orders of magnitude.) The triaxial conductivity tests measure the conductivity of the matrix not the conductivity of the fracture and from the results from the aquifer tests it is impossible to differentiate between the relative contributions of fracture or matrix flow.

In either case it appears that if the Tertiary sand aquifer was to be used to augment the supply currently extracted from the Quaternary limestone aquifer the imposed pumping stress would induce leakage causing a drop in the water level of the Quaternary limestone aquifer. It is therefore suggested that the Tertiary clay is not an effective confining layer under stressed conditions because of the variability between matrix and fracture flow. Further research would be necessary to provide additional information on the spatial variation of hydraulic properties and recharge rates to the system. A concurrent program looking at groundwater dating from both systems may provide additional information on the movement of water through the aquitard.

Results from drilling and previous investigations show that the Tertiary sand varies in its spatial distributions, water quality and yields. The thickness of Tertiary sand is greater in the Bramfield region, tending to become coarser with depth. The irregular basement highs in Kappawanta causes the thickness of Tertiary sand to be highly variable, with unpredictable yields and water quality. Nevertheless, considering the reasonably high transmissivity of the Tertiary sand aquifer there is a good potential for the aquifer to be utilised to augment the Quaternary limestone aquifer under the appropriate extraction scheme.

SUMMARY AND CONCLUSION

A preliminary investigation of the water resources of the Tertiary aquifer in County Musgrave shows that the hydraulic properties of the aquifer are spatially variable. Both Kappawanta and Bramfield proved to have a good supply of potable water beneath the unconfined aquifer. Difficulties do arise in determining the location of future sites for drilling due to the spatial variation of the sand in the aquifer and irregular basement highs. A comparison with the basement topography may assist in locating areas of thicker sand.

The quality of water from the Tertiary aquifer in all locations tested is certainly good enough to be used to augment the unconfined aquifer.

In summary this study has revealed that there is the potential for the Tertiary sand aquifer to be used to augment the supply in the unconfined Quaternary limestone aquifer. However, under stressed conditions the two aquifers are hydraulically connected and any design of a pumping scheme should take this constraint into account.

RECOMMENDATIONS

It is recommended that further investigations include:

- A review of the information currently available to isolate areas suitable for further investigation.

- Additional drilling and aquifer testing to enable a more complete understanding of the resources within the Tertiary aquifer, including the spatial variability of water quality and yield.

- Estimation of the amount of natural recharge to the Tertiary aquifer and the recharge mechanisms.

If the groundwater resources of the Tertiary aquifer are to be utilised then the following precautions are recommended:

- A well field of wells pumping at a low rate be used rather than single pumping sites. This will alleviate the problem of leakage from the unconfined aquifer. This could be achieved by the use of solar powered windmills

- Collector wells could be used to increase yields from the Tertiary aquifer.

- Regular monitoring of water levels and water quality of the Tertiary aquifer.

REFERENCES

Cooper, BJ, & Gatehouse, CG, 1983. *The Polda Trough: Periodic Sedimentation since the Proterozoic*. Abstracts of Geol. Soc. Aust. No. 9, p117-118, 6th Aust. Geol. Conv. Canberra, 1983.

Evans, S, March 1993. *Polda Lens Groundwater Study*. SA Energy and Water Supply Department. EWS Library Ref 93/9, EWS 3020/88.

Love, AJ, Dowie, J, Smith, PC, Dodds, S, Dennis, KJ, 1996, *Musgrave Proclaimed Wells Area Groundwater Assessment*. Department of Mines and Energy, SA. Report Book No 1996/10.

Painter, JAC, October 1970. *Eyre Peninsula Groundwater Study Co Musgrave Basins Progress Report No 19. Status of Investigations at 30th June 1970*. SA Department of Mines and Energy, Rept Bk No 70/157.

Smith, PC, December 1984. *Eyre Water Resources Study Groundwater Assessment Polda Basin*, SA Department of Mines and Energy, Rept Bk

Age	Unit Lithology	Occurrence	Hydrogeology
Pleistocene	**Bridgewater Formation:** calcareous sands, limestone, calcrete at surface, karstic	Widespread veneer over entire region, increases in thickness towards coast.	**Quaternary Limestone Unconfined Aquifer:** generally low salinity, karstic with variable permeability. Contains lithologies of the Bridgewater Formation. Often has semi-confining characteristics. Semi-continuous. Thickness 2-10m
Tertiary	**Unnamed Clay:** red to grey sand, gravel in parts.	Widespread through region.	**Tertiary Confining Bed:** Thin but continuous. Thickness 1-5m
Tertiary	**Poelpena Formation:** clayey sand near top, grading to a fine to coarse grained sand, minor carbonaceous and lignitic horizons.	Widespread; can form palaeochannel sands.	**Tertiary Sand Aquifer:** salinity varies from low to saline. Can be unconfined or confined - porous medium flow. Thicknesss 5 - 30m
Jurassic	**Polda Formation:** contains carbonaceous clay at top of sequence followed by sand,silts and clays	Only occurs in Polda Trough.	Confined Aquifer - generally very saline with low permeabilities
Permian	**Coolardie Formation:** predominantly claystone.	Only occurs on eastern margin of Polda Trough.	Only of minor importance.
Pre Cambrian	**Basement:** both weathered and crystalline gneisses, metasediments and granites.	Throughout the entire region.	**Basement:** contains both weathered and crystalline basement (undifferentiated) weathered basement, can contain brackish water with low yields

Table 1: Summary of Hydrostratigraphy (from Love et al, 1996)

Unit Number	OBS Number	Hund	Sect	Total Depth (m)	Final Depth (m)	Casing ID (mm)	Section Cased (m)	Completion Interval (m)	Water Cut (m)	SWL (m)	Salinity (ppm)
5930-1240	TAA 63	Talia	5	35.0	35.0	127.0	0-35.0	32-35m with 0.75mm screen	14.5 23.0	12.2 12.65	523.0 NA
5930-1235	TAA 62	Talia	30	35.0	34.8.	127.0	0-34.8	31.8-34.8m with 0.75mm screen	4.5 24.0	4.1 4.5	580.0 1285.0
5930-1236	KPW 82	Kappa-wanta	5	25.3	22.7	127.0	0-22.7	19.7-22.7 with 0.75mm screen	6.4 19.4	5.35 5.28	412.0 501.0
5930-1234	KPW 81	Kappa-wanta	5	25.0	20.0	76.0	0-20.0	19-20m slotted PVC & terra firma	7.0 19.0	6.05 6.15	445.0 556.0

Table 2: Summary of Drilling Information

Site	Depth (m)	Vertical Permeability (m/day)	Voids Ratio	Porosity	Moisture Content%	Specific Gravity	Dry density - Insitu (t/m^3)
TAA 63	16.00-16.10	4.4×10^{-6}	0.429	0.300	16.6	2.68	1.88
TAA 63	16.35-16.45	1.0×10^{-5}	0.318	0.241	10.8	2.66	2.02
TAA 63	16.95-17.05	1.1×10^{-4}	0.300	0.231	11.4	2.66	2.05
KPW 81	13.80-13.90	1.0×10^{-5}	1.033	0.508	35.8	2.74	1.35
KPW 81	14.10-14.20	2.7×10^{-5}	0.924	0.480	33.9	2.71	1.41

Table 3: Aquitard Permeability Test Results

Permit Number	Unit Number	Observation Number	Tertiary Aquifer Observation Bore Number	Distance From Pumped Bore (m)	Quaternary Aquifer Observation Bore Number	Distance From Pumped Bore (m)
32950	5930-1240	TAA 63	TAA 60	17.8	TAA 61	15.5
32951	5930-1235	TAA 62	TAA 58	15.0	TAA 59	15.8
32952	5930-1236	KPW 82			KPW 78	12.0
32953	5930-1234	KPW 81	KPW 72	17.8	KPW 38	

Table 4: Summary of site details

Bore Number	Year of Test	*Transmissivity (m^3/day/m)	Storage Coefficient	Pumping Rate (m^3/day)
Wells Completed With Screens. (This Report)				
TAA 63	1995	115	1.7×10^{-4}	518
TAA 62	1995	21	1.9×10^{-4}	242
KPW 82	1995	54		138
5930-1077	1991	270		657
Monitoring Wells. (This Report)#				
HUD 55	1995	3.1 to 6.3		17.3
TAA 41	1995	8.5		28.8
WAD 30	1995	1.0 to 7.0		17.3
Painters Pump Tests (1972)				
PT 8	1970	80-270	1×10^{-3} to 1.1×10^{-2}	670
Adopted Values		80	1×10^{-3}	
PT 10	1970	50-300	1×10^{-3} to 1.8×10^{-2}	670
Adopted Values		80	1×10^{-3}	

Table 5: Summary of Aquifer Tests
* Average Transmissivity values from constant discharge and step tests.
# Completed with terra firma and slotted casing.

	TAA 63	TAA 62	KPW 82
Sodium (mg/l)	200	280	90
Potassium (mg/l)	24	8	5
Calcium (mg/l)	45	63	36
Magnesium (mg/l)	20	20	10
Iron (Total) (mg/l)	<0.01	<0.01	<0.01
Silicon (mg/l)	7.6	6.9	11
Carbonate (mg/l)	< 5	< 5	< 5
BiCarbonate (mg/l)	319	331	276
Chloride (mg/l)	310	480	140
Sulphate (mg/l)	65	135	30
pH	7.06	7.24	7.4
Conductivity (uS/cm)	1540	2210	956
TDS (mg/l)	990	1325	600

Table 6: Full analyses from aquifer tests (taken at end of aquifer tests).

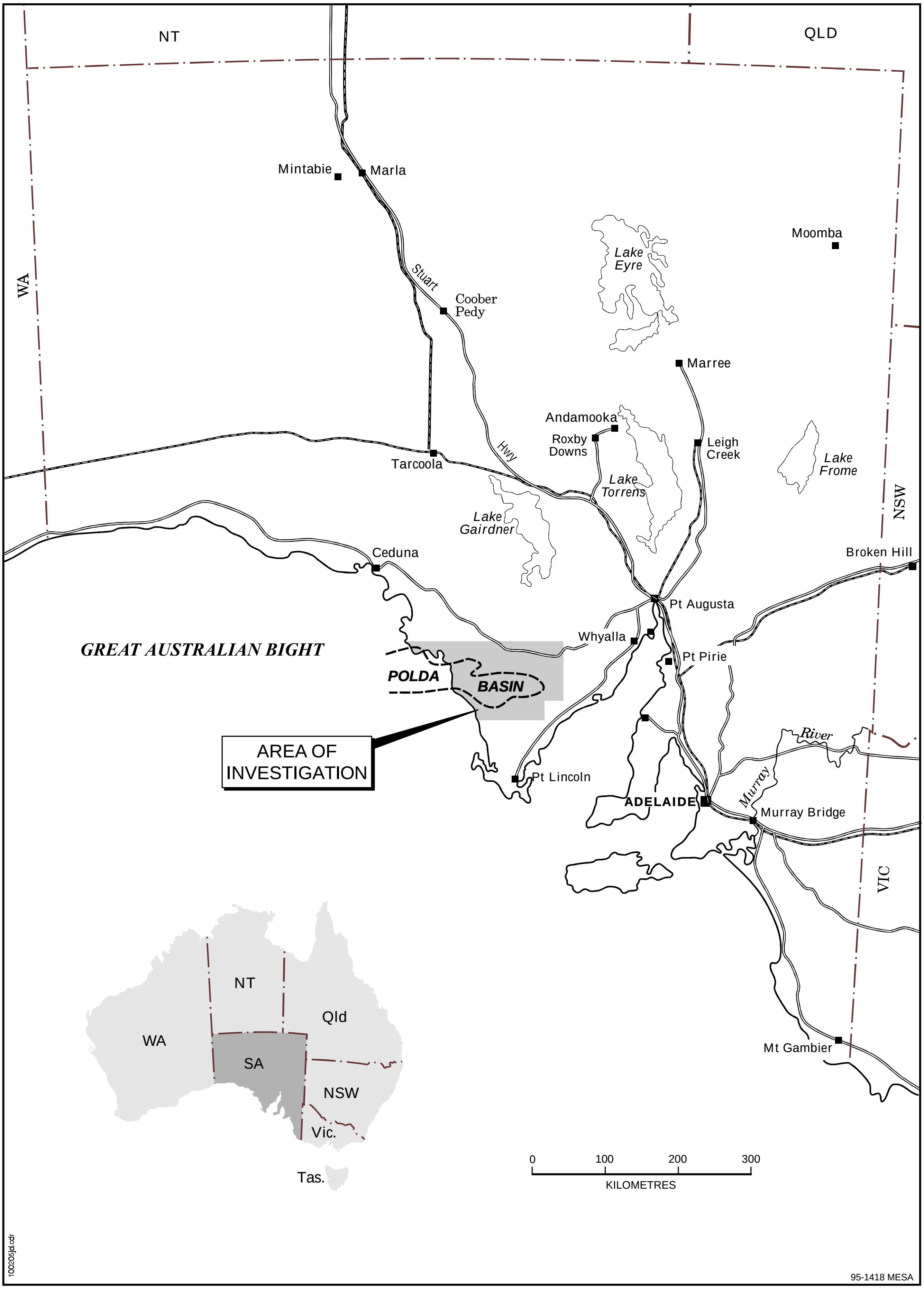

Fig. 1 County Musgrave Tertiary sand investigation, locality plan

Job No. 100205

MINES and ENERGY RESOURCES SOUTH AUSTRALIA

COUNTY MUSGRAVE TERTIARY SAND INVESTIGATION

WELL LOCATION PLAN

Figure.......2

1995–1419

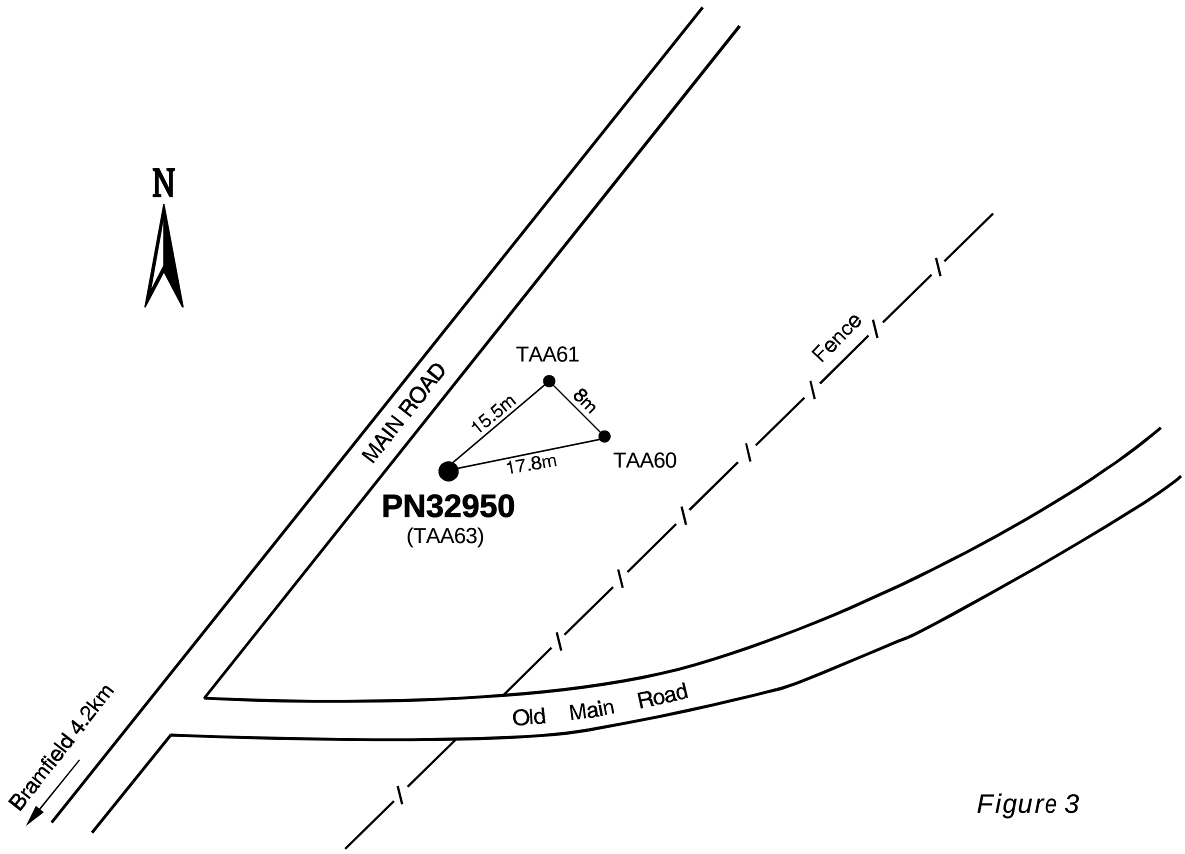

Figure 3

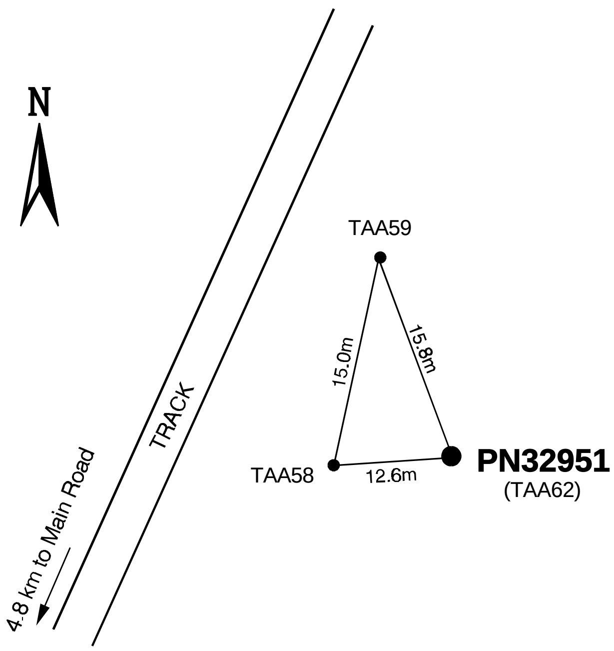

Figure 4

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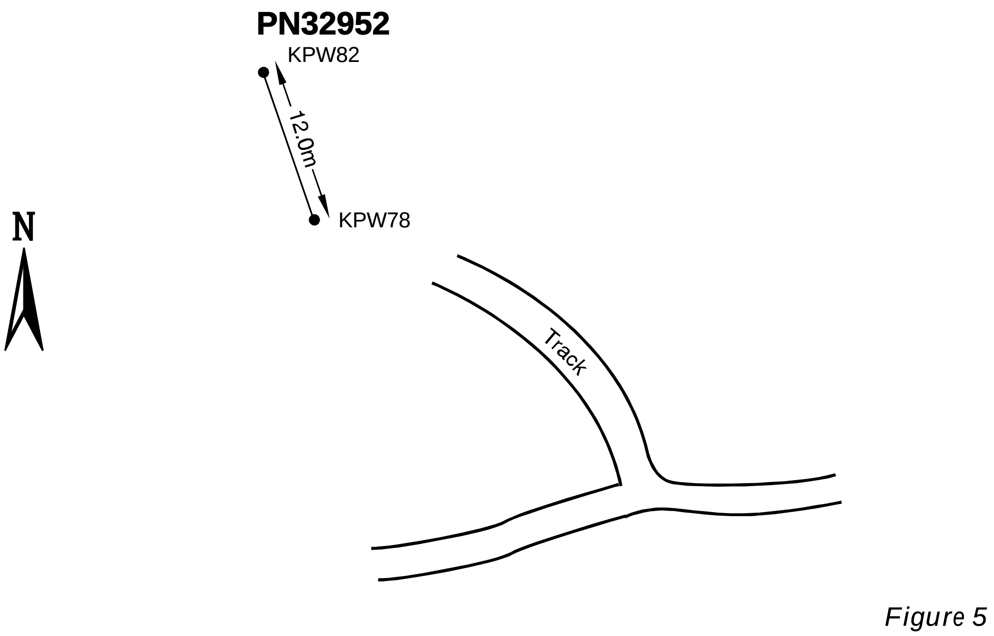
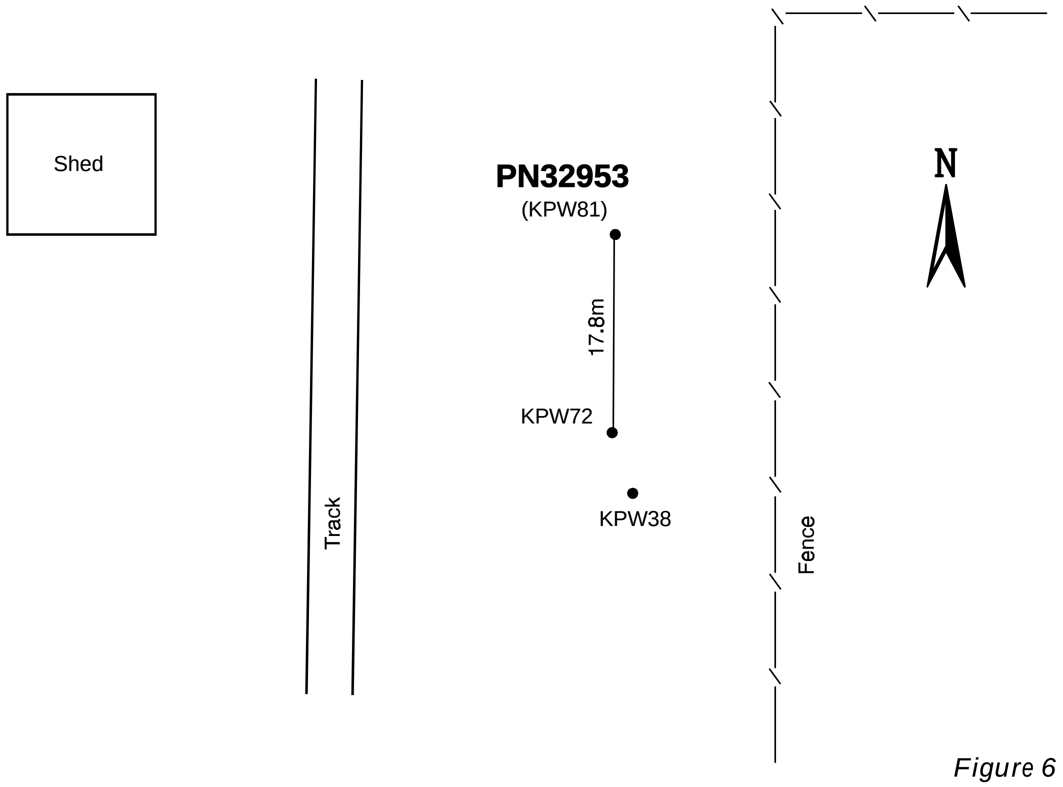
Figs 3 and 4, County Musgrave Tertiary sand investigation, site sketch for boreholes TAA63 and TAA62





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Figs 5 and 6 County Musgrave Tertiary sand investigation, site sketch for boreholes KPW 82 and KPW81

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DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA
GROUNDWATER AND ENGINEERING SECTION

PLAN No. 1995–1425

COMPOSITE WELL LOG – GROUNDWATER

CONSTRUCTION DETAILS

DRILLING METHOD . . CABLE TOOL
CIRCULATION . . . . WATER
MUD RESISTIVITY/TYPE . . . . .
START . . . . FINISH . . . .
TOTAL DEPTH . . 25.0 . . . m

	mm	From (m)	To (m)
HOLE DIAMETER	76	0.0	20.0
CASING DIAMETER (Cemented)	76	15.0	16.5
CASING DIAMETER (Uncemented)	76	0.0	15.0
	76	15	19
SCREEN DETAILS	76	19.0	20.0

GROUNDWATER ANALYSES

DEPTH TO WATER CUT (m)	DEPTH TO S.W.L. (m)	YIELD m³/day	YIELD Method of Test	TOTAL DISSOLVED SOLIDS mg/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
7.0	6.05			445	
19.0	6.10			590	

REMARKS

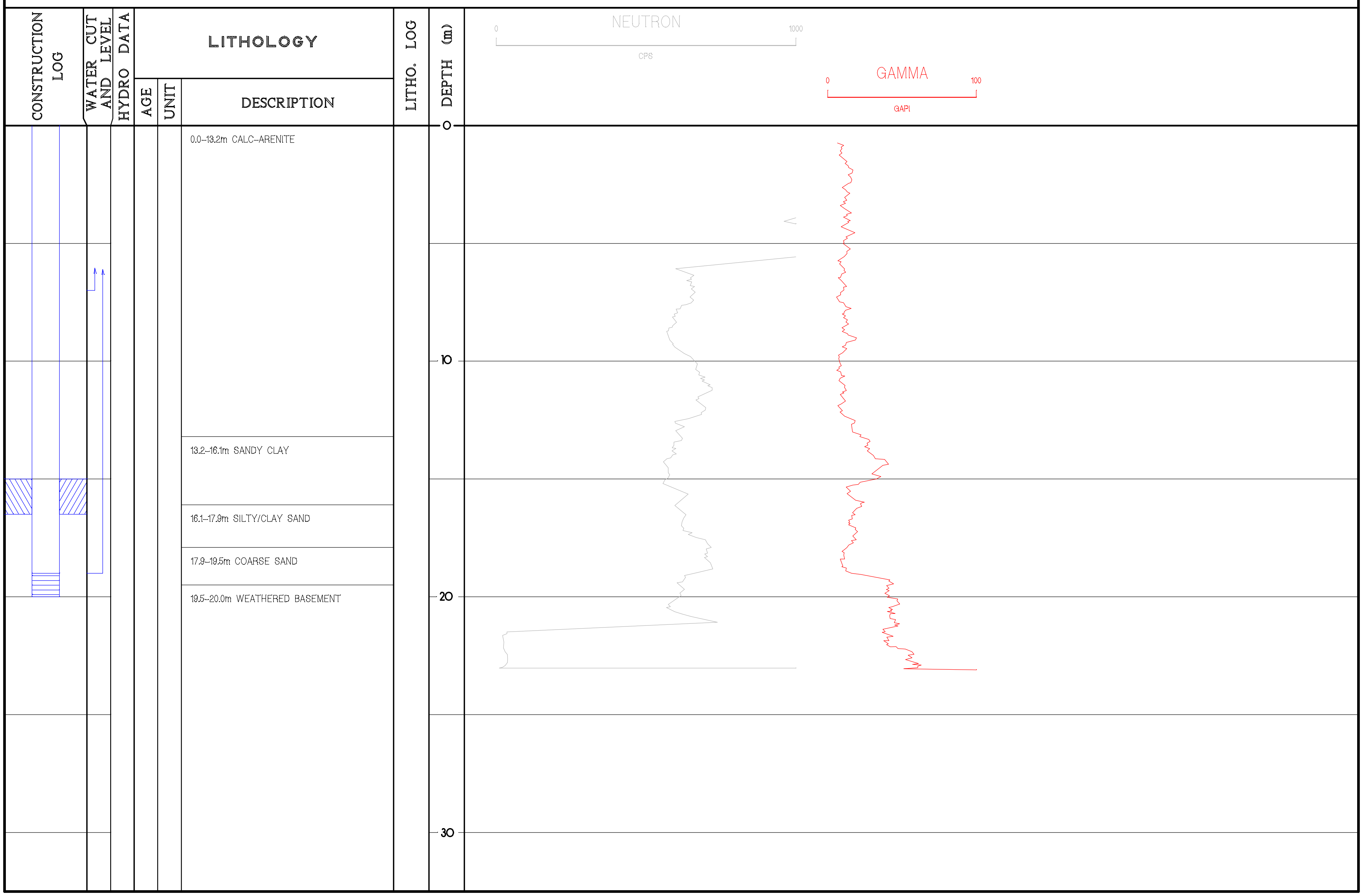
PROJECT . . . . County Musgrave – Tertiary Sand Aquifer Investigation . . . .
FIELD No. . . . . UNIT No. 5930–1234 . . . . . . PERMIT No. 32953B . . .
LOCATION . . . KAPPAWANTA . . . .
REF. ELEV. 60.037 m SURFACE ELEV. 59.414 m DATUM . . . .
LOGGED BY . . J. DOWIE . . . DATE . . 27–1–95 . . . .

GEOPHYSICS

TYPE OF LOG	Gamma	Neutron						
DATE OF RUN	27–1–95	27–1–95						
FIRST READING (m)	0.8	5.5						
LAST READING (m)	23.0	23.0						
RECORDED BY	B TAYLOR	B TAYLOR						

WELL SYMBOLS

Casing seal
Casing shoe
Wire wound screen
Slotted casing
Cemented interval
Gravel packed interval



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DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

GROUNDWATER AND ENGINEERING SECTION

PLAN No. 1995–1423

COMPOSITE WELL LOG - GROUNDWATER

CONSTRUCTION DETAILS

DRILLING METHOD . . CABLE TOOL
CIRCULATION . . . . WATER
MUD RESISTIVITY/TYPE . . .
START . . . . FINISH . . . .
TOTAL DEPTH . . 35.0 . . . m

	mm	From (m)	To (m)
HOLE DIAMETER	127		
CASING DIAMETER (Cemented)	127	9.5	12.0
CASING DIAMETER (Uncemented)	127	0	9.5
		12.0	32.0
SCREEN DETAILS 0.75mm Wire Wound	127	32.0	35.0

GROUNDWATER ANALYSES

DEPTH TO WATER CUT (m)	DEPTH TO S.W.L. (m)	YIELD m³/day	YIELD Method of Test	TOTAL DISSOLVED SOLIDS mg/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
4.5	4.1				
24.0	4.5				

REMARKS

PROJECT . . . . County Musgrave – Tertiary Sand Investigation . . . .
FIELD No. . . . . UNIT No. 5930–1235 . . . . . . PERMIT No. 32951 . . . .
LOCATION . . . COUNTY MUSGRAVE . . . .

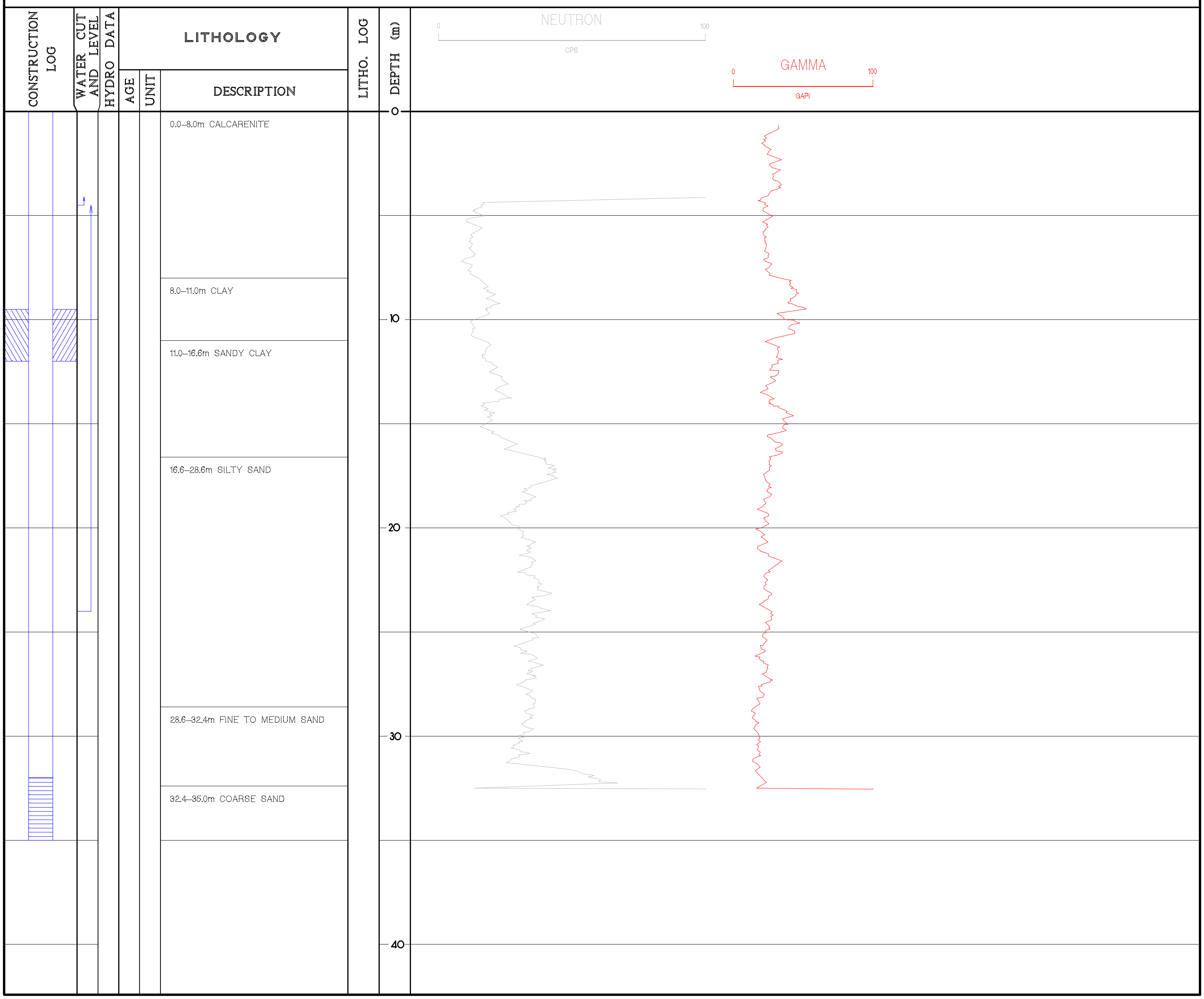
REF. ELEV. 20.657 m SURFACE ELEV. 20.401 m DATUM . . . .
LOGGED BY . . J DOWIE . . . DATE . . 15–12–94 . . .

GEOPHYSICS

TYPE OF LOG	Gamma	Neutron						
DATE OF RUN	17–1–95	17–1–95						
FIRST READING (m)	0.8	4.4						
LAST READING (m)	32.5	32.5						
RECORDED BY	B TAYLOR	B TAYLOR						

WELL SYMBOLS

. . . Casing seal
. . . Slotted casing
. . . Casing shoe
. . . Cemented interval
. . . Wire wound screen
. . . Gravel packed interval



Job No. 100205

PLAN No. 1995–1424

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA
GROUNDWATER AND ENGINEERING SECTION

COMPOSITE WELL LOG – GROUNDWATER

CONSTRUCTION DETAILS

DRILLING METHOD . . CABLE TOOL
CIRCULATION . . . . WATER
MUD RESISTIVITY/TYPE
START . . . . FINISH . . . .
TOTAL DEPTH . . 25.3 . . . m

	mm	From (m)	To (m)
HOLE DIAMETER			
CASING DIAMETER (Cemented)	127	8.4	8.7
		18.7	19.7
CASING DIAMETER (Uncemented)	127	0.0	8.4
		8.7	17.7
		18.7	19.7
SCREEN DETAILS 0.75mm Wire Wound	127	19.7	22.7

GROUNDWATER ANALYSES

DEPTH TO WATER CUT (m)	DEPTH TO S.W.L. (m)	YIELD		TOTAL DISSOLVED SOLIDS	
		m³/day	Method of Test	mg/litre	Analysis W. No.
6.4	5.35			412	
19.4	5.28			500	

REMARKS

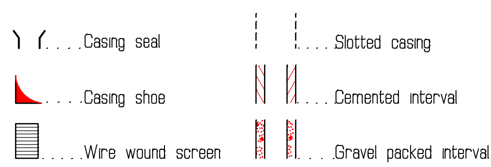
GEOPHYSICS

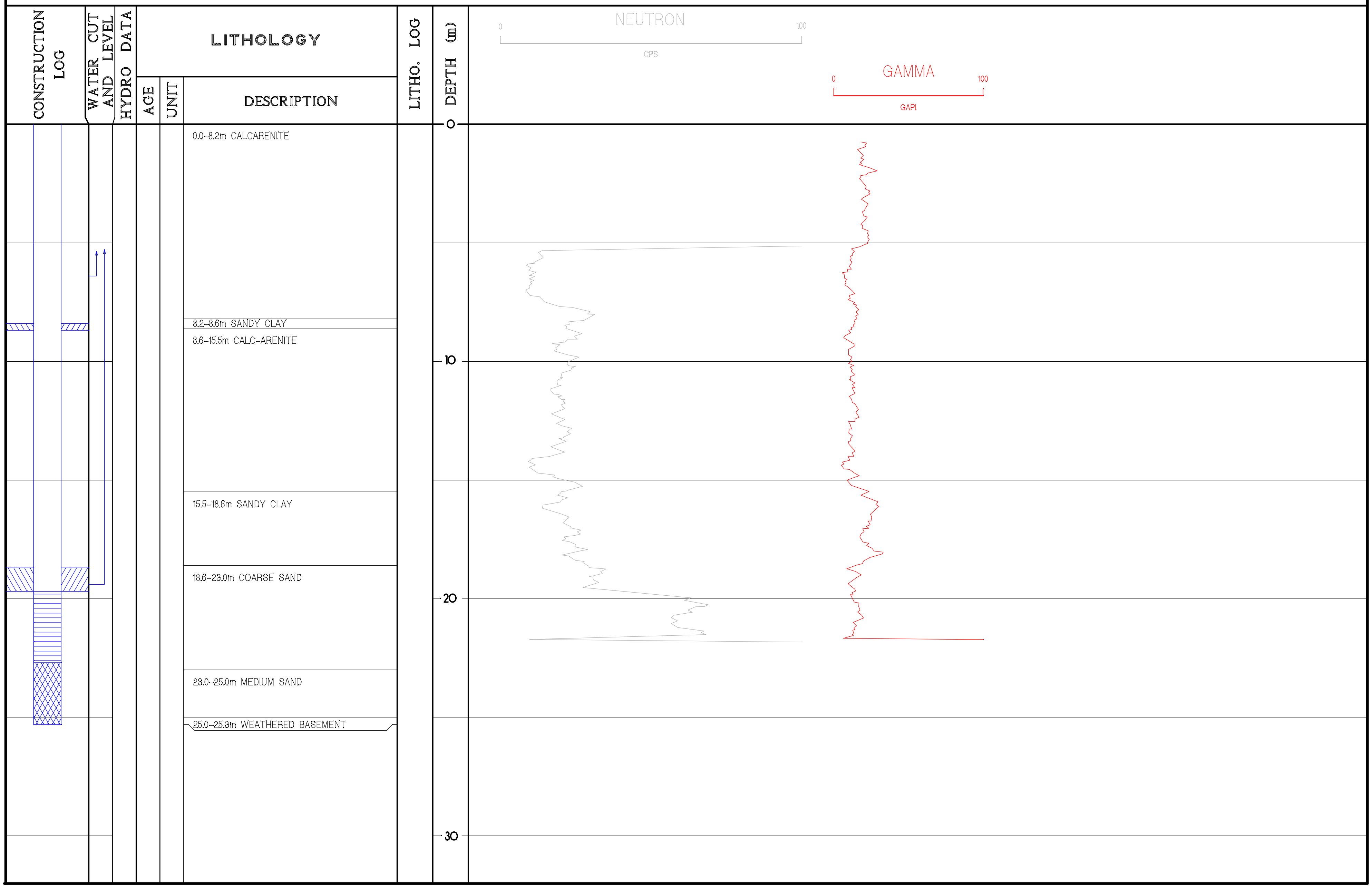
TYPE OF LOG	GAMMA	NEUTRON					
DATE OF RUN	27–1–95	27–1–95					
FIRST READING (m)	0.8m	5.4					
LAST READING (m)	21.6	21.6					
RECORDED BY	B TAYLOR	B TAYLOR					

PROJECT . . . . County Musgrave–Tertiary Sand Aquifer Investigation . . . . . .
FIELD No. . . . . UNIT No. 5930–1236 . . . . . . PERMIT No. 32952 . . . .
LOCATION . . . KAPPAWANTA . . . .

REF. ELEV. 57.931 m SURFACE ELEV. 57.517 m DATUM . . . .
LOGGED BY . . J. DOWIE . . . DATE . . 23–1–95 . . . .

WELL SYMBOLS





100205JD.DTA

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA
GROUNDWATER AND ENGINEERING SECTION

PLAN No. 1995–1422

COMPOSITE WELL LOG - GROUNDWATER

PROJECT County Musgrave - Tertiary Sand Investigation
FIELD No. .... **UNIT No.** 5930-1240 ...... **PERMIT No.** 32950
LOCATION HUNDRED of TALIA

REF. ELEV. 28.181 **m** **SURFACE ELEV.** 27.782 **m** **DATUM** ....
LOGGED BY J DOWIE **DATE** 10-1-95

CONSTRUCTION DETAILS

DRILLING METHOD: CABLE TOOL
CIRCULATION: WATER
MUD RESISTIVITY/TYPE:
START: FINISH:
TOTAL DEPTH: 35.0 m

	mm	From (m)	To (m)
HOLE DIAMETER			
CASING DIAMETER (Cemented)	127	15.1	17.0
CASING DIAMETER (Uncemented)	127	0.0	15.1
	127	17.0	32.0
SCREEN DETAILS 0.75mm Wire Wound	127	32.0	35.0

GROUNDWATER ANALYSES

DEPTH TO WATER CUT (m)	DEPTH TO S.W.L. (m)	YIELD m³/day	YIELD Method of Test	TOTAL DISSOLVED SOLIDS mg/litre	TOTAL DISSOLVED SOLIDS Analysis W. No.
14.5	12.2				
23.0	12.25				

REMARKS

GEOPHYSICS

TYPE OF LOG	Gamma	Neutron						
DATE OF RUN	17-1-95	17-1-95						
FIRST READING (m)	0.2	12.0						
LAST READING (m)	33.8	33.8						
RECORDED BY	B TAYLOR	B TAYLOR						

WELL SYMBOLS

Casing seal
Casing shoe
Wire wound screen
Slotted casing
Cemented interval
Gravel packed interval

CONSTRUCTION LOG | WATER CUT AND LEVEL | HYDRO DATA | AGE | UNIT

LITHOLOGY

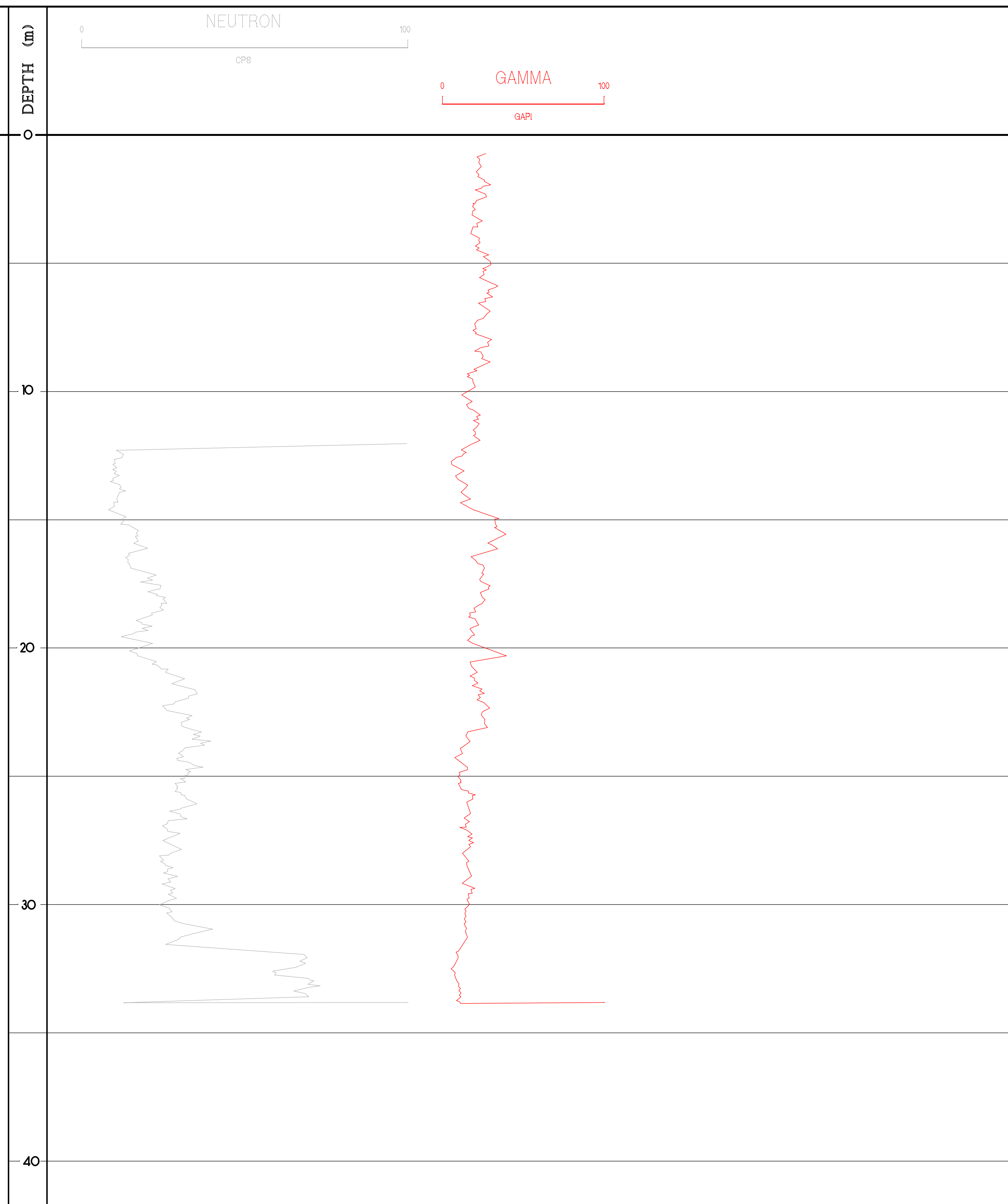
DESCRIPTION | LITHO. LOG | DEPTH (m)

0.0–14.5m CALCARENITE

14.5–22.5m CLAY/SANDY CLAY

22.5–32.0m SILTY SAND

32.0–35.0m COARSE SAND



AQUIFER TEST ANALYSES

TAA 63

The well was successfully developed then allowed to recover prior to the commencement of pump tests. Initially some sand was pumped from the well, but this quickly cleared.

Step- Drawdown Test

The step test was conducted in three 100 minute stages. A semi-log plot of drawdown versus time (figure B-1) was used to determine a well equation in the form:

$$St = aQ + cQ^2 + bQ\log_{10}t$$

Where:
St = drawdown (m)
Q = discharge rate (m^3/min)
t = time (min)
a & b = constants related to laminar flow within the aquifer
c = constant related to turbulent well loss

From fig B-1 the following equation was derived:

$$St = 14.7Q + 3.1Q^2 + 2.1Q\log_{10}t$$

From this equation the parameter b relates to aquifer loss. The lower the value of b the more efficient the aquifer. Parameters a and c are indicators of well loss and therefore can be used to determine how efficiently the well was completed.

Transmissivity values were also calculated from the step tests and are presented in table B-1.

Main Test (24 hour test)

A constant discharge test was conducted for a period of 24 hours (1440 mins) at a flow rate of 6 l/sec. A semi-log plot of drawdown versus time for the production well (fig B-2) and the observation well (fig B-3), and a log/log plot (fig B-4) of the observation well, were used to calculate transmissivity (Table B-1). Storativity of the aquifer was calculated from the log/log plot only. It was not possible to calculate Storativity from the semi-log plot due to high initial well loss in both the production well and observation well, and the leaky conditions of the aquifer.

Figure B-2 shows the initial well loss followed by a steady drawdown. At approximately t = 100 minutes the drawdown starts to decrease and by t = 700 mins there is almost no more drawdown. This is caused by leakage to the confined aquifer from the above unconfined aquifer. The well equation is therefore only accurate until approximately 250 minutes. At t = 100 minutes the error between the calculated drawdown and observed drawdown is 0.4 %, by t = 250 min the error is 3.5% and by t = 700 min the error is 6.1%.

TAA 62

TAA 62 was developed for a period of approximately 11 hours. At the end of the development period a small amount of sand and silt was still being pumped out of the well. This was particularly noticeable at the start of pumping.

Step Test

The step test was conducted in three 100 minute stages. From the semi-log plot of drawdown versus time (figure B-5) the following equation was derived:

$St = 98.8Q + 59Q^2 + 12.4Q\log_{10}t$

The values of a and c show that the well is inefficient, particularly with regard to screen selection. Screens were selected prior to drilling to avoid lengthy delays in rig time, so this problem was unavoidable. During drilling it was found that a depth restriction of 35m was imposed due to technical difficulties. Had the well been drilled deeper into the coarse sand then the well may well have been more successful. Unfortunately the top 10 to 20 centimetres of the screen is in a finer grained sand where the majority of well inefficiencies would be centred.

The high value of b in the well equation is predominantly due to the low transmissivity of the aquifer

The well equation therefore has a degree of inaccuracy. At t = 10 mins the error between the observed drawdown and the calculated drawdown is 0.1 %, at t = 100 min the error is 3.3 %, and by t = 400 the error is 7.6 %. The well equation is therefore only of use up until approximately t = 200 minutes. The reason for the large degree of inaccuracy is that the well equation does not take leakage during aquifer testing into account.The well equation therefore provides a conservative estimate of drawdown.

Main Test

A constant discharge test was conducted for a period of 24 hours (1440 min) at a flow rate of 2.8 l/s.

From the semi-log plot of drawdown versus time for the production well (figure B-6) and the observation well (fig B-7) transmissivity and storativity values have been calculated (table B-2). Figure B-6 shows a high initial well loss followed by a steadily decreasing water level. At approximately t = 200 min, minimal drawdown is evident. This is assumed to be due to leakage from the unconfined aquifer above.

KPW 82

Step Test

The step test consisted of three 100 minute stages. From the semi-log plot of drawdown versus time (figure B-8) the following equation was derived:

$St = 79.1Q + 20Q^2 + 4.9Q\log_{10}t$

From this equation parameter b indicates some aquifer loss. The constants a and c indicate a considerable amount of well loss.

This equation can be used to calculate drawdown until approximately t = 900 mins, when leakage starts to influence drawdown.

Transmissivity results are shown in Table B-3.

Main Test

A constant discharge test was conducted for a period of 24 hours (1440 mins). Transmissivity values were determined from the semi-log plot of drawdown versus time (fig B-9) and are presented in Table B-3.

The erratic drawdown behaviour in figure B-9 could be as a result of low flow rates during the pump test (Q = 1.6 l/s), or due to poor development of the well, causing a problem with mobilisation of fines.

5930-1077

A constant discharge test was conducted on this well in 1991 for a period of 1100 minutes. From the semi-log plot of drawdown vs time (fig B-10) a transmissivity of 267 m^3/d/m was calculated. As can be seen from fig B-10, at a time of t = 700 mins there is no further drawdown. This is assumed to be due to leakage from the unconfined aquifer.

Observation Wells

Three of the observation wells which are monitored monthly were pump tested for short time periods. All of these well are completed with slotted casing with a terra firma packing. The semi-log plots of drawdown versus time are presented in figures B-11 to B-13 and the results of the tests are presented in Table B-4. The transmissivity values calculated should be treated with caution as they do not represent accurate values due to terra firma completions and partial penetration. The tests were done in order to determine the spatial variability in the Tertiary aquifer. Of the 8 observation wells tested only 3 were successful. The other 5 sites were unsuccessful due to rapid drawdown followed by forking. It is assumed these wells were either completed in Tertiary sand with a low transmissivity or have extremely poor well efficiency. The 3 successful sites may be suitable as sites for further investigation and may also serve as suitable sites for future aquifer tests.

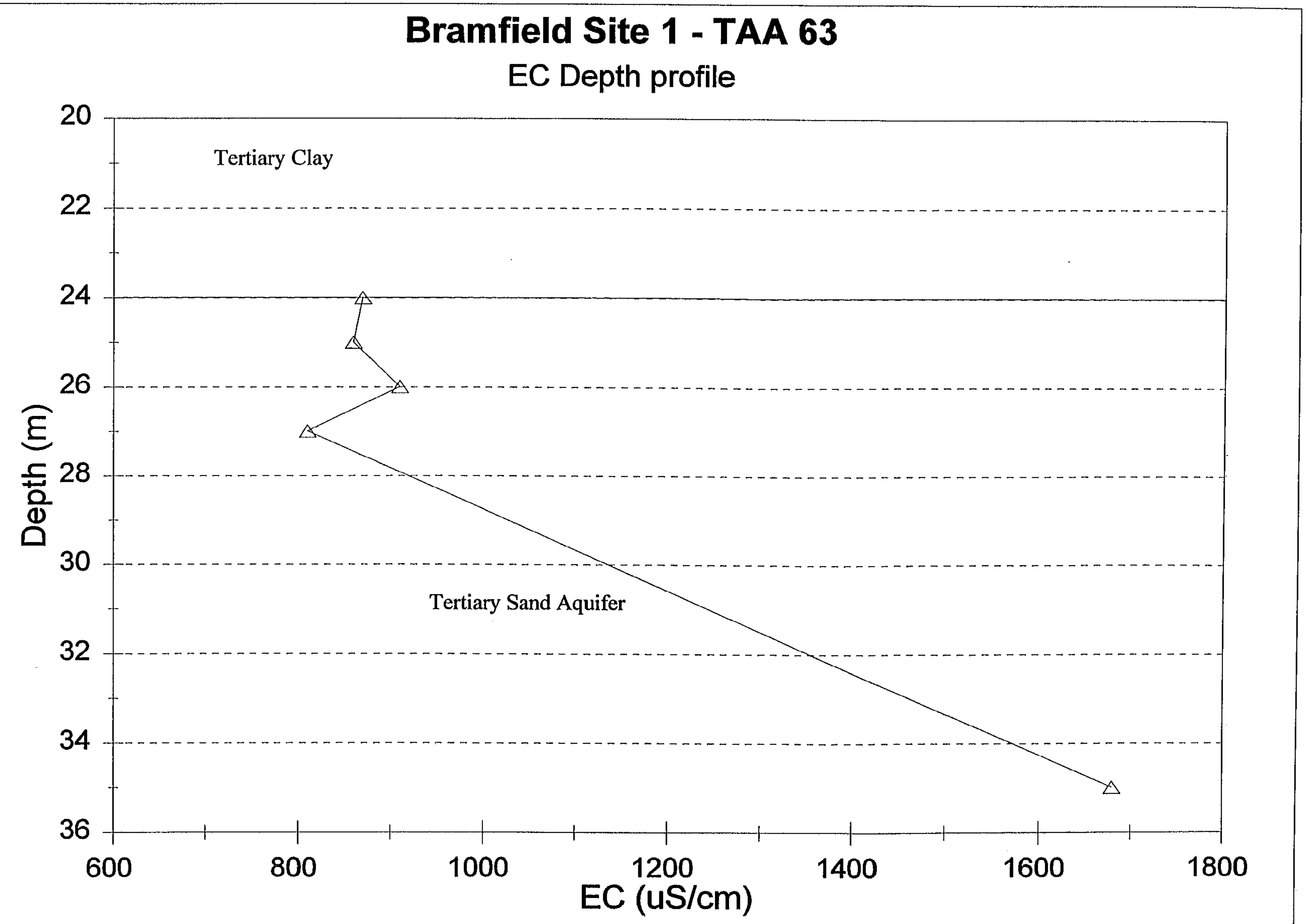


Figure 7: EC Depth Profile TAA 63

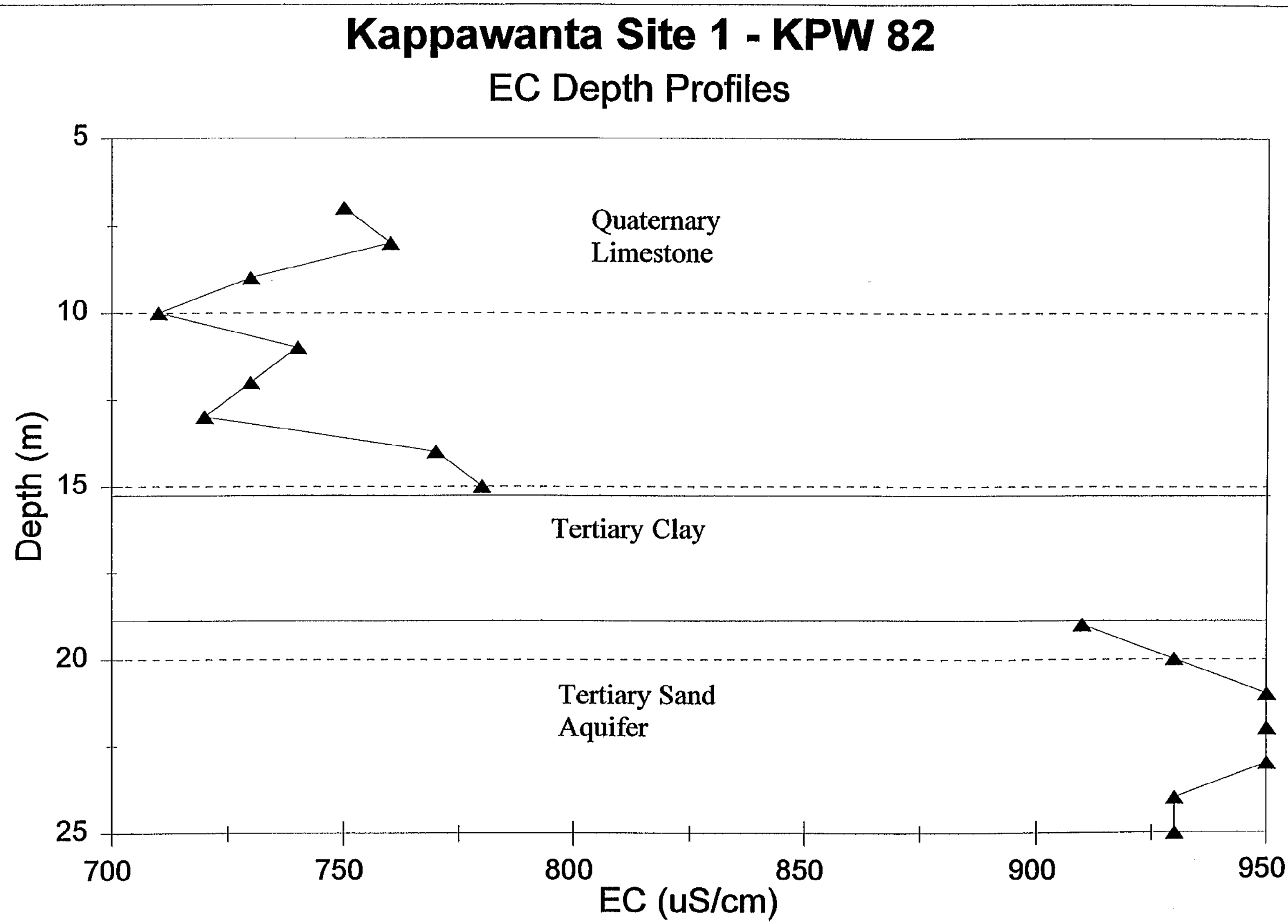


Figure 8: EC Depth Profile KPW 82

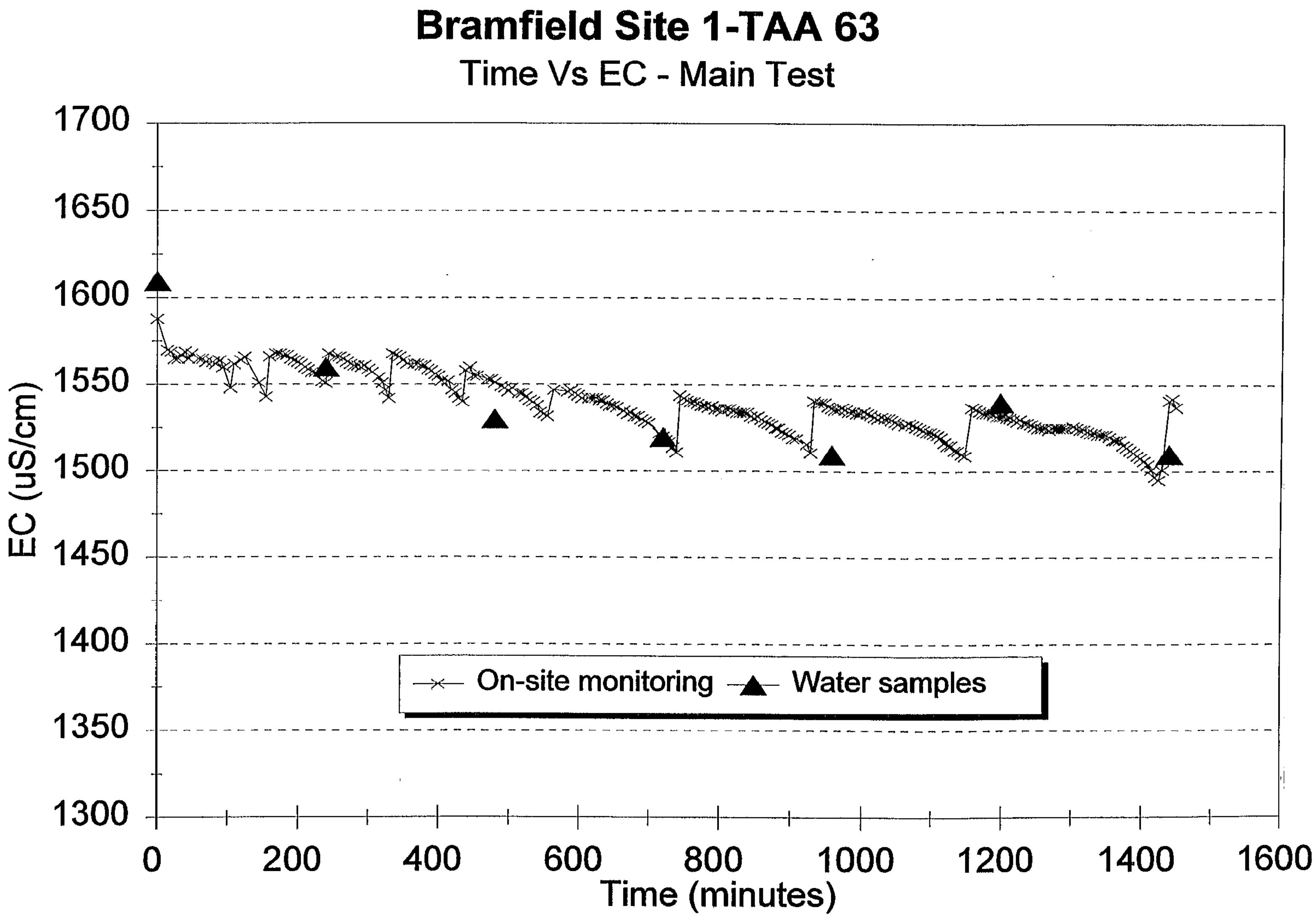


Figure 9: EC Versus Time TAA 63

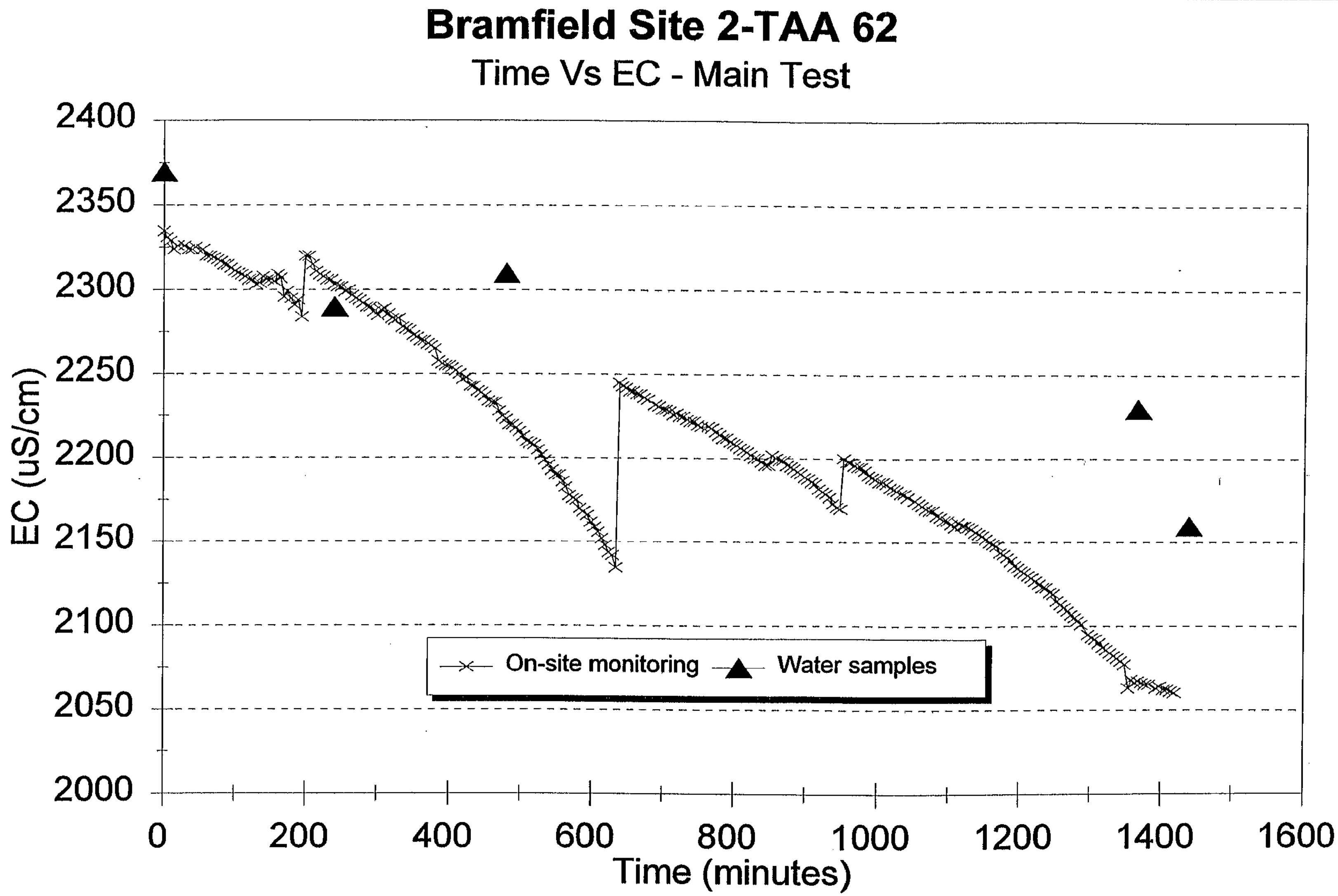


Figure 10: EC Vs Time TAA 62

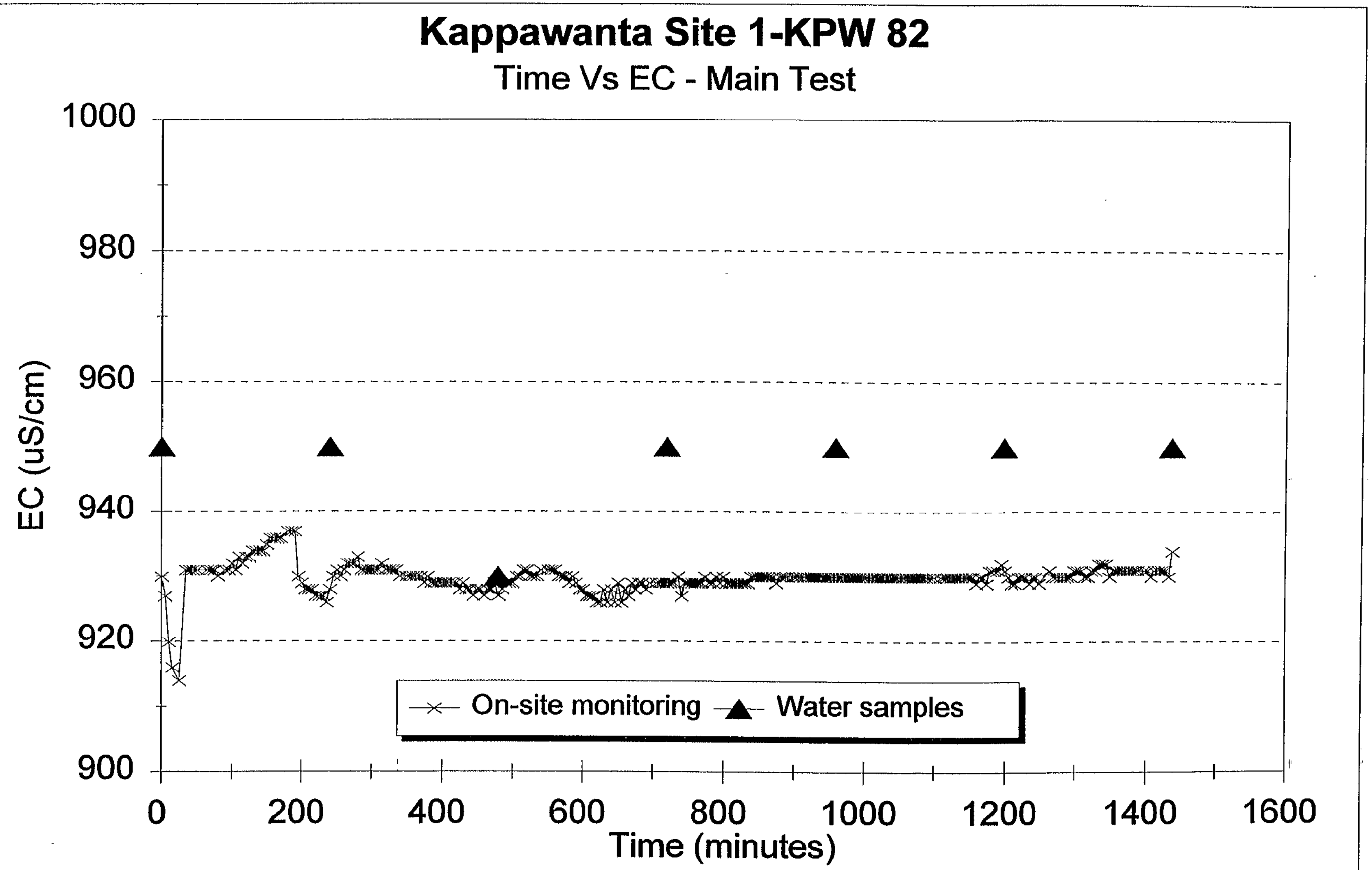


Figure 11: EC Versus Time KPW 82

APPENDIX A

Geological and Geophysical Logs

PROJECT: County-Musgrave

LOCATION OR COORDS:

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

WATER WELL LOG

GROUNDWATER DIVISION

PERMIT NO: PN32950

UNIT NO:5930-1240

Hundred: WARD Sec: 5

El. Surface (m): 27.782 El.Ref.Point (m): 28.181 Datum:

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY l/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/ltr	TOTAL DISSOLVED SOLIDS Analysis No:
	14.50	12.2						523.0	
	23.0	12.25	32.0	35.0	> 6.0 l/sec	24 hrs	Pump Test	855.0	

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
10	14.5		Calc-Arenite	– Off-white, moderately to very well cemented calcarenite. Subangular to subrounded, very fine to medium grained quartz. Subangular limestone grains and shell fragments in a limestone matrix.			127.0mm	0	
14.5	22		Clay to Sandy Clay	– Brown to off-white plastic clay. Contains fine to medium grained quartz, increasing in content towards base of clay. Minor limestone content with calcarenite fragments up to 5 cm towards bases of the clay. Iron nodules present at 16.8, becoming more common towards 18.0m. Grading to an off-white sandy clay. Quartz grains clear to opaque, fine to medium, subrounded quartz grains. Quartz sand and silt content increasing towards 22.0 m		cement plug		15.1	17.0
22	25		Silty Sand	– Light brown to fawn silty sand. Subangular to subrounded, clear to opaque quartz grains. Medium to fine grained, up to 2.0mm. Silt content decreasing towards 25m. Average grainsize = 0.3-0.4mm. Minor fine feldspars.					

REMARKS: Cores taken from 15.70 m to 17.85m

DRILL TYPE: Cable Tool

COMPLETED: 20/12/94

CIRCULATION: Water

LOGGED BY: John Dowie

Figure A1: Geological Log TAA 63

DATE: 21/12/94

SHEET 1 OF 2

GROUNDWATER DIVISION

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

WATER WELL LOG

CONTINUATION SHEET

PERMIT NO: PN 32950
UNIT NO: 5930-1240
DME TAA 63

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia (mm)	CASING From (m)	CASING To (m)
25.0	31.7		Silty Sand	– Light brown to fawn silty quartz sand. Quartz grains subangular to rounded, clear to opaque, up to 0.7mm diameter. Average grainsize = 0.2-0.25mm increasing to 0.4mm at 32m. Silt content approximately 20%.			127 mm		
31.7	35.0		Coarse Sand	– Reddish brown, silty coarse sand. Subangular to subrounded, clear to opaque grains up to 3.5mm in diameter. Average grainsize = 0.65-0.75mm, increasing to 1.0mm at 35m.			Wire Screen (0.75mm)	32.0	35.0

Water Samples

15m = 950 uS	26m = 850 uS
19m = 869 uS	27m = 835 uS
20m = 877 uS	
24m = 840 uS	
25m = 860 uS	

NB/ all average grainsize values were done as visual estimates in the field.

PROJECT: County-Musgrave

LOCATION OR COORDS:

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

WATER WELL LOG

GROUNDWATER DIVISION

PERMIT NO: 32951

UNIT NO:5930-1235

Hundred: Talia Sec: 30

El. Surface (m): 20.401 El.Ref.Point (m): 20.657 Datum:

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY l/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/ltr	TOTAL DISSOLVED SOLIDS Analysis No:
	4.50	4.10m						560	
	24.0	4.50m	32	35	2.8	24 hrs	pump	1250	

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	4		Calc-Arenite	- Off-white, moderately to very well cemented calcarenite. Fine to medium grained, subangular to subrounded limestone fragments and subangular to subrounded quartz grains (5%) in a calcareous matrix. Minor shell fragments present. Contains discrete bands of calcrete, notably at 2.5 and 6.5m			127.00		
4	6		Calc-Arenite	- As Above - Matrix more silty. Quarttz grains up to 15%. Minor ironstones, up to 2mm in diameter.					
6	8		Calc-Arenite	- Light brown, moderately indurated calcarenite. Fine to coarse, subrounded limestone fragments and quartz grains in a calcareous matrix. Quartz grains approx 25%. Minor ironstones, up to 3mm diameter.					
8	9.5		Clay	- Light brown, plastic marly clay with subangular to subrounded, fine to med quartz and limestone grains. Minor fine ironstones (up to 0.4mm)					
9.5	11		Clay	- Stiff brown clay with fine to medium rounded quartz grains. Minor calcrete fragments, up to 5mm diameter.		cement plug		9.5	
11	16.6		Sandy Clay	- Reddish brown, unconsolidated, fine to medium, angular to subrounded quartz grains in a silty clay matrix. Minor quartz grains up to 1.5mm diameter. Nodules of firm white clay, with clear quartz grains, up to 2.0mm. Clay and silt content decreases towards 16m,					12.0

REMARKS:

DRILL TYPE: Cable Tool

COMPLETED: 14/12/95

CIRCULATION:

LOGGED BY: J. Dowie

Figure A2: Geological Log TAA 62

DATE:15/12/94

GROUNDWATER DIVISION

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

WATER WELL LOG

CONTINUATION SHEET

PERMIT NO: 32951

UNIT NO:

DME

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia (mm)	CASING From (m)	CASING To (m)
16.6	21		Silty Sand	- Brown, moderately sorted, subangular to subrounded quartz sand. Average grainsize = 0.2-0.25mm with grains up to 1.0mm. Minor ironstones up to 2.0mm. Silt content approx 20%			127.00		
21	26		Silty Sand	- Fawn to white silty quartz sand. Quartz grains are clear, subangular to rounded and moderately sorted. Average grainsize = 0.25-0.3mm, with grains up to 1.5mm. Silt content 5-10%. Very minor feldspars, mica and ironstones present.					
26	28.6		Silty Sand	- Light brown to fawn, silty quartz sand. Moderately to well sorted, angular to subrounded quartz grains, up to 0.7mm. Average grainsize = 0.3mm. Silt content minor. Minor feldspars and mica.					
28.6	32.4		Fine to Medium Sand	- Fawn coloured quartz sand. Grains clear to opaque, subrounded, average grainsize = 0.35mm to 0.4mm, with minor grains up to 1.0mm. Very minor silt, feldspars and mica.					
32.4	35		Coarse Sand	- White to pale fawn quartz sand. Clear, subangular to rounded with average grainsize = 0.5mm with more than 23% greater than 1.0mm. Feldspars up to 5% - pink, subangular, up to 0.5mm		Wire Screen (0.75mm)		32.0	35.0

Water Samples

5m = 1410 uS	24m = 1020 uS
7m = 1070 uS	25m = 1010 uS
8m = 1020 uS	26m = 1070 uS
9m = 1010 uS	28m = 1120 uS
10m = 980 uS	29m = 1150 uS

NB/ All grainsize values were done as visual estimates in the field.

PROJECT: County Musgrave

LOCATION OR COORDS:

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

WATER WELL LOG

GROUNDWATER DIVISION

PERMIT NO: 32952

UNIT NO: 5930-1236

Hundred: Kappawanta Sec: 5

El. Surface (m): 57.517 El.Ref.Point (m): 57.931 Datum:

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY l/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/ltr	TOTAL DISSOLVED SOLIDS Analysis No:
	6.40m	5.35m						412	
	19.40m,,	5.28m	19.7	22.7	1.6	24 hrs	pump	500	

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	8.4		Calc-Arenite	- Off white, moderately to very well cemented calcarenite. Fine to medium grained, subangular to subrounded, clear to opaque quartz grains in a calcareous matrix. Contains minor shell fragments up to 0.3mm, and minor ironstones, up to 0.2mm.			127.00		
8.4	8.7		Sandy Clay	- Brown plastic clay containing, and interbedded with clear to opaque, subrounded to rounded, fine to medium sand, up to 0.7mm.		cement plug		8.40	8.7
8.7	15.5		Calc-Arenite	- Off white, moderately cemented calcarenite. Contains limestone and calcrete fragments, and quartz grains in a calcareous matrix. Quartz grains are clear to opaque, subrounded to rounded, fine to medium grained. Contains a large amount of silt. Increasing quartz content towards 15.5m Minor shell fragments and very small gastopods. Minor ironstones.					
15.5	18.6		Sandy Clay	- Off white, plastic clay containing abundant quartz grains. Quartz grains are subangular to subrounded, clear to opaque, fine to medium grained. Contains horizons of iron stained clay. Quartz grains become coarser and more predominant towards 19.0m Minor calcareous content at top of clay. Contains large chunks (up to 10 cm) of calcrete and calcarenite, not present below 17.0m Ironstone nodules common, fine to very coarse, becoming finer towards 19.0m		cement plug		17.7	18.7

REMARKS:

Figure A3: Geological Log KPW 82

DRILL TYPE: Cable Tool (CT 3)

CIRCULATION: Water

DATE:23/01/95

COMPLETED: 21/01/95

LOGGED BY:J Dowie

SHEET 1 OF 2

GROUNDWATER DIVISION

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

WATER WELL LOG

CONTINUATION SHEET

PERMIT NO: 32952
UNIT NO:
DME

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia (mm)	CASING From (m)	CASING To (m)
18.6	23.0		Coarse Sand	- Off white to fawn coarse quartz sand. Subangular to rounded, clear, with minor opaques. Grain size ranges from fine to fine gravel with a minor silt content. Silt content increases towards 23m. Average grainsize = 0.7-0.8mm. Minor horizons of poorly consolidated brown, medium grained sand.		Wire Screen (1.75mm)		19.7	22.7
23.0	25.0		Medium Sand	- Reddish, brown, medium grained quartz sand. Subangular to rounded, clear quartz grains, up to 3.0mm. Average grainsize = 0.4mm decreasing to 0.25mm at 25.0m. Large silt content, brown in colour and increasing in content towards 25.0m Minor ironstones, up to 0.8mm, becoming more common towards 25.0m		Backfilled to 22.7m			
25.0	25.3		Weathered Basement	- Massive, tight, plastic white clay containing subangular clear quartz grains, up to 1.5mm in diameter. Interbedded with reddish brown plastic clay containing weathered feldspars and quartz.					

Water Samples

7m = 750 uS	16m = 780 uS
8m = 760 uS	17m = 780 uS
9m = 730 uS	19m = 910 uS
10m = 710 uS	20m = 930 uS
11m = 740 uS	21m = 950 uS
12m = 730 uS	22m = 950 uS
13m = 720 uS	23m = 950 uS
14m = 770 uS	24m = 930 uS
15m = 780 uS	25m = 930 uS

NB/ All grainsize values were done as visual estimates in the field

PROJECT: County Musgrave

LOCATION OR COORDS:

DEPARTMENT OF MINES AND ENERGY – SOUTH AUSTRALIA

WATER WELL LOG

GROUNDWATER DIVISION

PERMIT NO: 32953B

UNIT NO: 5930–1234

Hundred: Kappawanta Sec: 5

El. Surface (m): 59.414 El.Ref.Point (m):20.037 Datum:

AQUIFER SUMMARY:	DEPTH TO WATER CUT (m)	DEPTH TO STANDING WATER (m)	INTERVAL (m) From	INTERVAL (m) To	SUPPLY l/sec	SUPPLY Test length	SUPPLY Method	TOTAL DISSOLVED SOLIDS mg/ltr	TOTAL DISSOLVED SOLIDS Analysis No:
	7.0m	6.05m						445	
	19m	6.15m						590	

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK/SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION/AGE		CASING Dia (mm)	CASING From (m)	CASING To (m)
0	8		Calcarenite	– Moderately to very well cemented, orangy/red to fawn coloured calcarenite. Subangular to rounded, clear to opaque, fine to medium quartz grains and angular limestone fragments in a calcareous matrix. Abundant fine ironstones decreasing in abundance towards 8.0m. Minor horizons of calcrete – most notably at 5–5.5m.			76.0mm		
8	9		Clay and Calcarenite	– Light to dark brown, stiff to moderately plastic clay, containing subangular to rounded, clear to opaque, fine to medium grained quartz, and angular limestone and calcaenite fragments. Interbedded with very hard, well cemented, off white to pink calcarenite.					
9	13.1		Calcarenite	– Off white, well cemented calcarenite. Subangular to rounded, clear to opaque, fine to medium quartz grains in a limestone matrix.					
13.1	17		Sandy Clay	– Orange/brown to khaki, sticky, stiff clay. Fine to medium grained, subangular to subrounded, clear to opaque quartz grains, and angular limestone and calcarenite fragments. Quartz grains increasing in size and content towards 17.0m					
17	19		Silty Clayey Sand	– Fawn to light brown, silty sand. Clear, subangular to subrounded, fine to coarse sand. Grtains up to 1.0mm. Ave grainsize = 0.2mm increasing to 0.35mm at 18.0m. Minor blobs of khaki clay. Large amount of silt. Minor, fine ironstones.		cement plug		15.0	16.5

REMARKS: Cored from 13.30 to 14.46m

1st core 13.3 to 13.6m 2nd core 13.6 to 13.9m 3rd core 13.9 to 14.2m 4th core 14.2 to 14.46m

Figure A4: Geological Log KPW 81

DRILL TYPE: Cable Tool (CT3)

CIRCULATION: Water

DATE: 30/01/95

COMPLETED: 27/01/95

LOGGED BY: J. Dowie

SHEET 1 OF 2

GROUNDWATER DIVISION

DEPARTMENT OF MINES AND ENERGY - SOUTH AUSTRALIA

WATER WELL LOG

CONTINUATION SHEET

PERMIT NO: 32953B

UNIT NO: 5930-1234

DME: KPW 81

DEPTH (m) From	DEPTH (m) To	GRAPHIC LOG	ROCK / SEDIMENT NAME	GEOLOGICAL DESCRIPTION	FORMATION / AGE	DEPTH CORE SAMPLE	CASING Dia (mm)	CASING From (m)	CASING To (m)
17.9	19.5		Silty Coarse Sand	- Brown, Subrounded to rounded, poorly sorted, clear quartz sand. Average grainsize = 0.3-0.4mm with grains up to 3.5mm. Considerable silt content. Blobs of moderately consolidated brown sandy clay. Sand is fine to medium, clear, angular to subangular quartz grains.		Slotted casing with terra firma	76.00	19.0	20.0
19.5	24		'Weathered Basement ' Clay	- Brown to khaki, sticky, stiff to plastic clay. Quartz grains clear, subangular to subrounded, fine to medium grained with horizons of ironstained sandy clay. Quartz grains becoming coarser and more angular towards 24m. Minor mica, chlorite, fine pink feldspars and fine ferrugenous fragmentsnd from 22 to 22.1m. Abundant weathered pink feldspars and chlorite towards 24.0m.		Backfilled to 20m			
24	25		Basements Sands and Gravel	- Angular, fine to fine gravel, subangular, opaque quartz grains. Abundant pink to red, coarse to fine gravel sized feldspars. Abundant mica.					

Water Samples

8m = 810 uS	15m = 820 uS
9m = 770 uS	16m = 810 uS
10m = 840 uS	17m = 820 uS
11m = 840 uS	18m = 820 uS
12m = 830 uS	19m = 830 uS
13m = 820 uS	20m = 1010 uS

NB/ All grainsize values were done as visual estimates in the field.

APPENDIX B

Aquifer Test Results

TEST	PUMPING RATE - Q			Transmiss-ivity (m³/d/m)	Storativity	Max Draw down	Specific Capacity (m³/d/m)
	m³/day	m³/min	litre/sec				
First Stage	172.8	0.12	2.0	127		2.3	75.1
Second Stage	345.6	0.24	4.0	115		4.7	73.5
Third Stage	518.4	0.36	6.0	119		7.2	72.0
Main Test							
-Drawdown	518.4	0.36	6.0	119		7.4	70.1
-Recovery	518.4	0.36	6.0	113			
-Obs Bore	518.4	0.36	6.0	112		2.42	
Log/Log -Obs Bore	518.4	0.36	6.0	92	1.7×10^{-4}		
Average				115	1.7×10^{-4}		72.7

Table B-1: Summary of pump test analysis for TAA 63

TEST	PUMPING RATE - Q			Transm-issivity (m³/d/m)	Storativity	Max Draw down	Specific Capacity (m³/d/m)
	m³/day	m³/min	litre/sec				
First Stage	86.4	0.06	1.0	23		7.62	11.3
Second Stage	172.8	0.12	2.0	20		15.49	11.2
Third Stage	241.92	0.168	2.8	21		21.64	11.2
Main Test							
-Drawdown	241.92	0.168	2.8	21		22.37	10.8
-Recovery	241.92	0.168	2.8	22			
-Obs Bore	241.92	0.168	2.8	21	1.9×10^{-4}		
Average				21	1.9×10^{-4}		11.1

Table B-2: Summary of pump test analysis for TAA 62

TEST	PUMPING RATE - Q			Transmiss -ivity (m^3/d/m)	Max Drawdown	Specific Capacity (m^3/d/m)
	m^3/day	m^3/min	litre/sec			
First Stage	51.84	0.036	0.6	53.0	3.24	16.0
Second Stage	103.68	0.072	1.2	54.0	6.58	15.8
Third Stage	155.52	0.108	1.8	54.0	9.99	15.6
Main Test						
-Drawdown	138.24	0.096	1.6	53.0	9.16	15.1
-Recovery	138.24	0.096	1.6	53.0		
Average				54.0		15.6

Table B-3: Summary of pump test analysis for KPW 82

Bore No	Pumping Rate			Transmi-ssivity (m^3/d/m)	Max Drawdown (m)	Specific Capacity (m^3/d/m)
	m^3/day	m^3/min	l/sec			
PN 95802	656.64	0.456	7.6	267.0	6.87	95.6
TAA 41	28.80	0.020	0.33	8.5	4.33	6.7
HUD 55	17.28	0.012	0.20	3.0-6.3	3.02	5.7
WAD 30	17.28	0.012	0.20	1.0-7.0	6.57	2.6

Table B-4: Summary of pump test analysis for PN 95802 and Observation Bores.

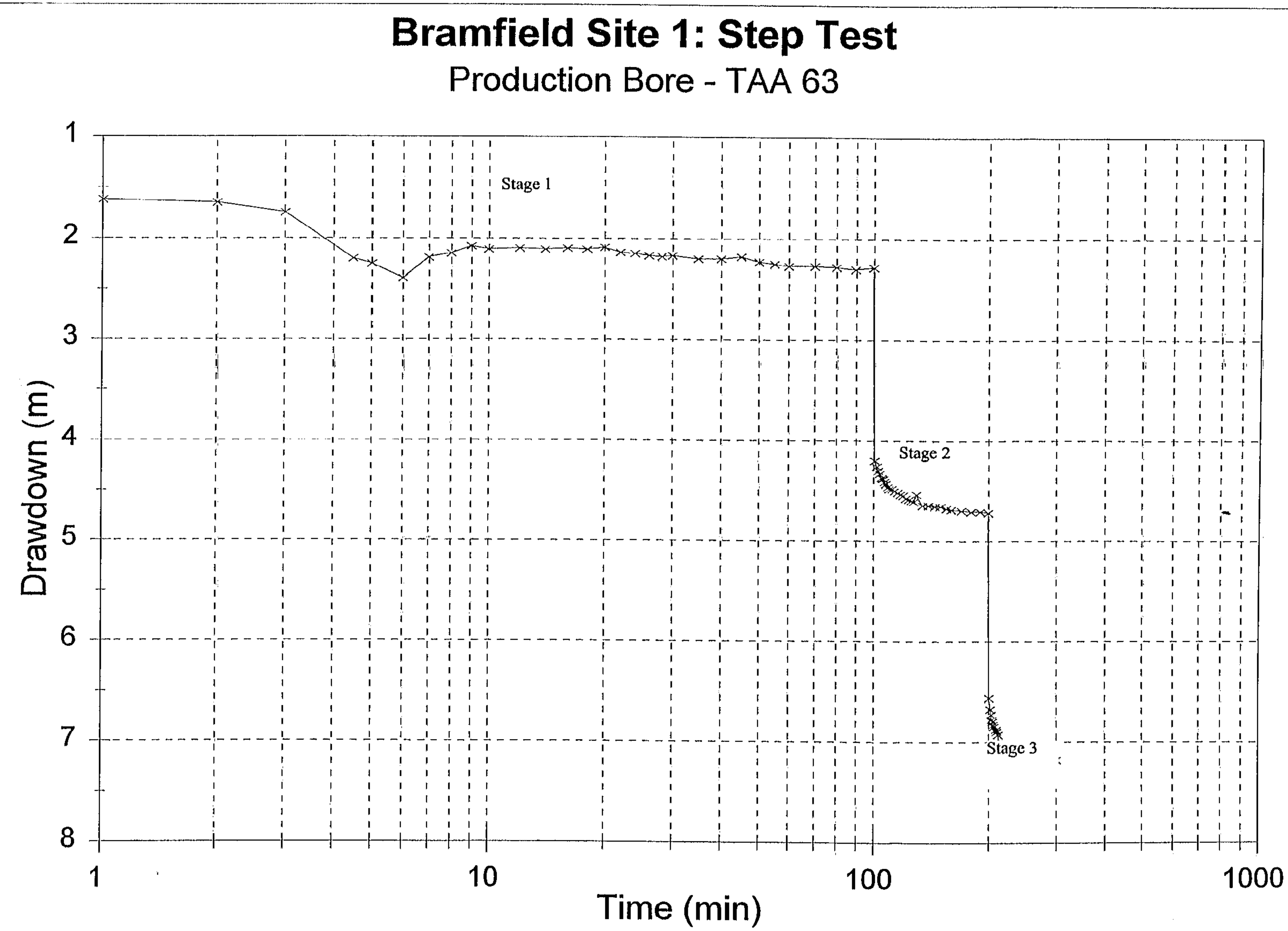


Figure B1: Drawdown Vs Time for step test - TAA 63

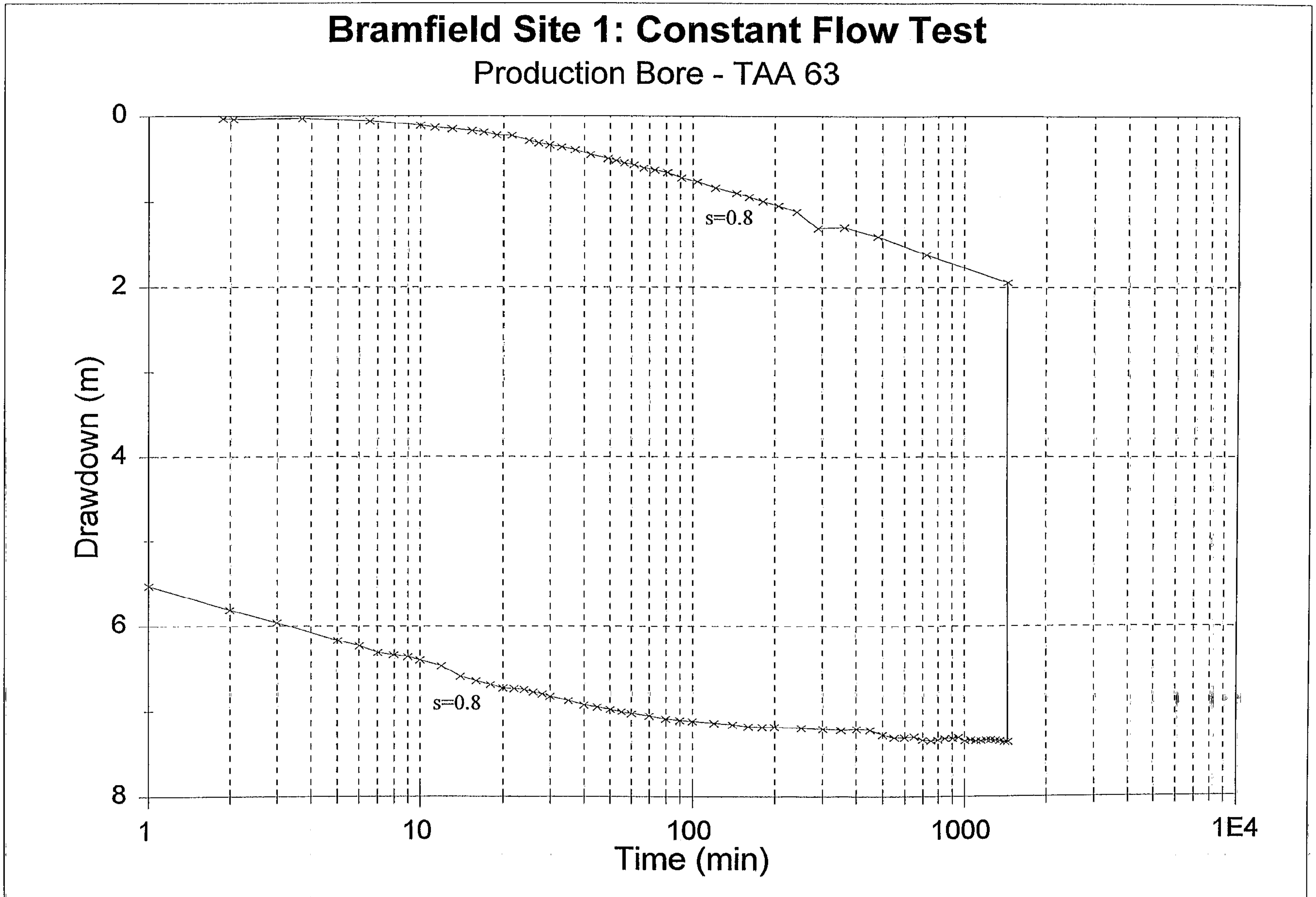


Figure B2: Drawdown Vs Time for Constant Flow Test - TAA 63

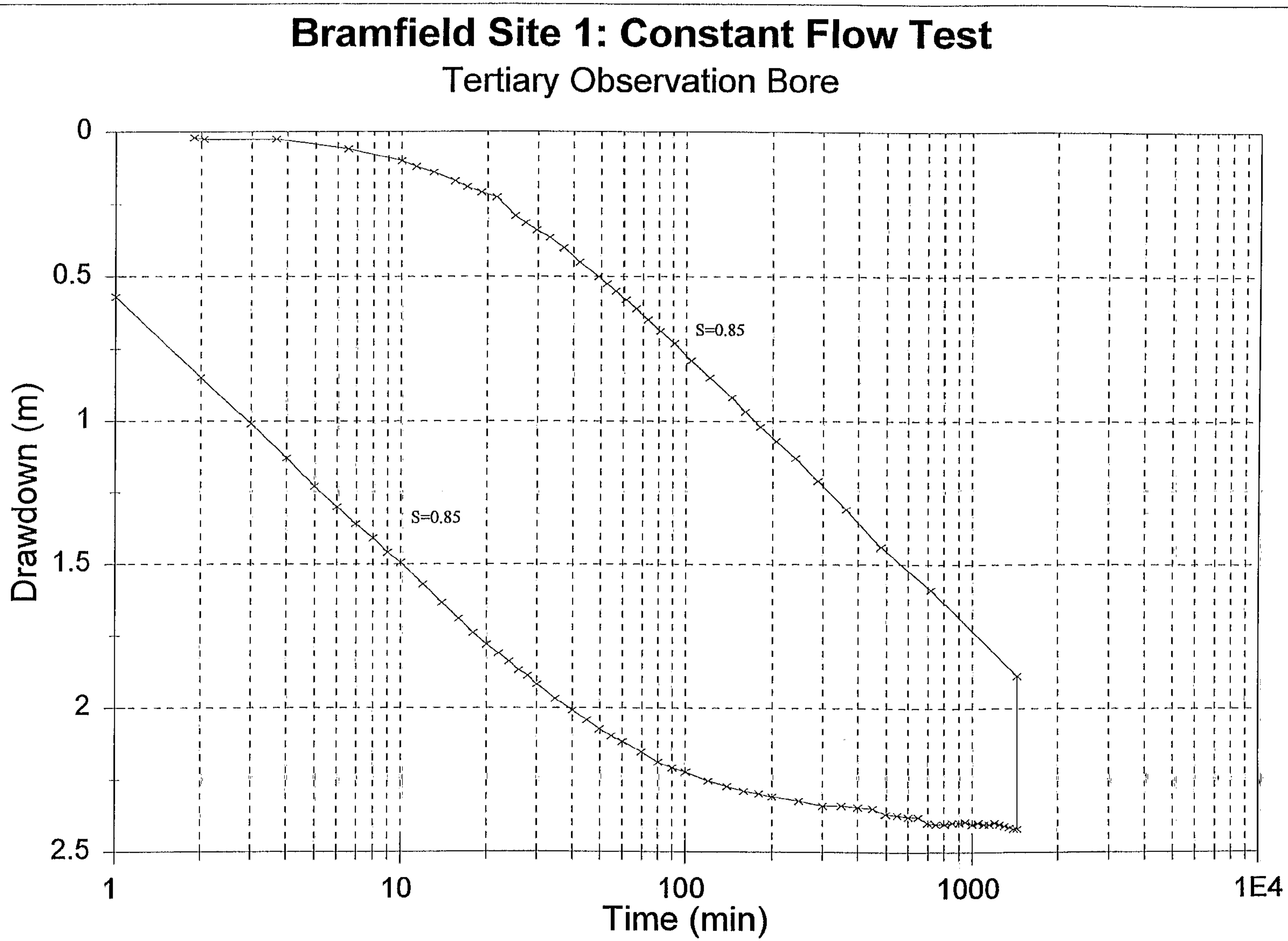


Figure B3: Drawdown Vs Time for Constant Flow Test - TAA 60

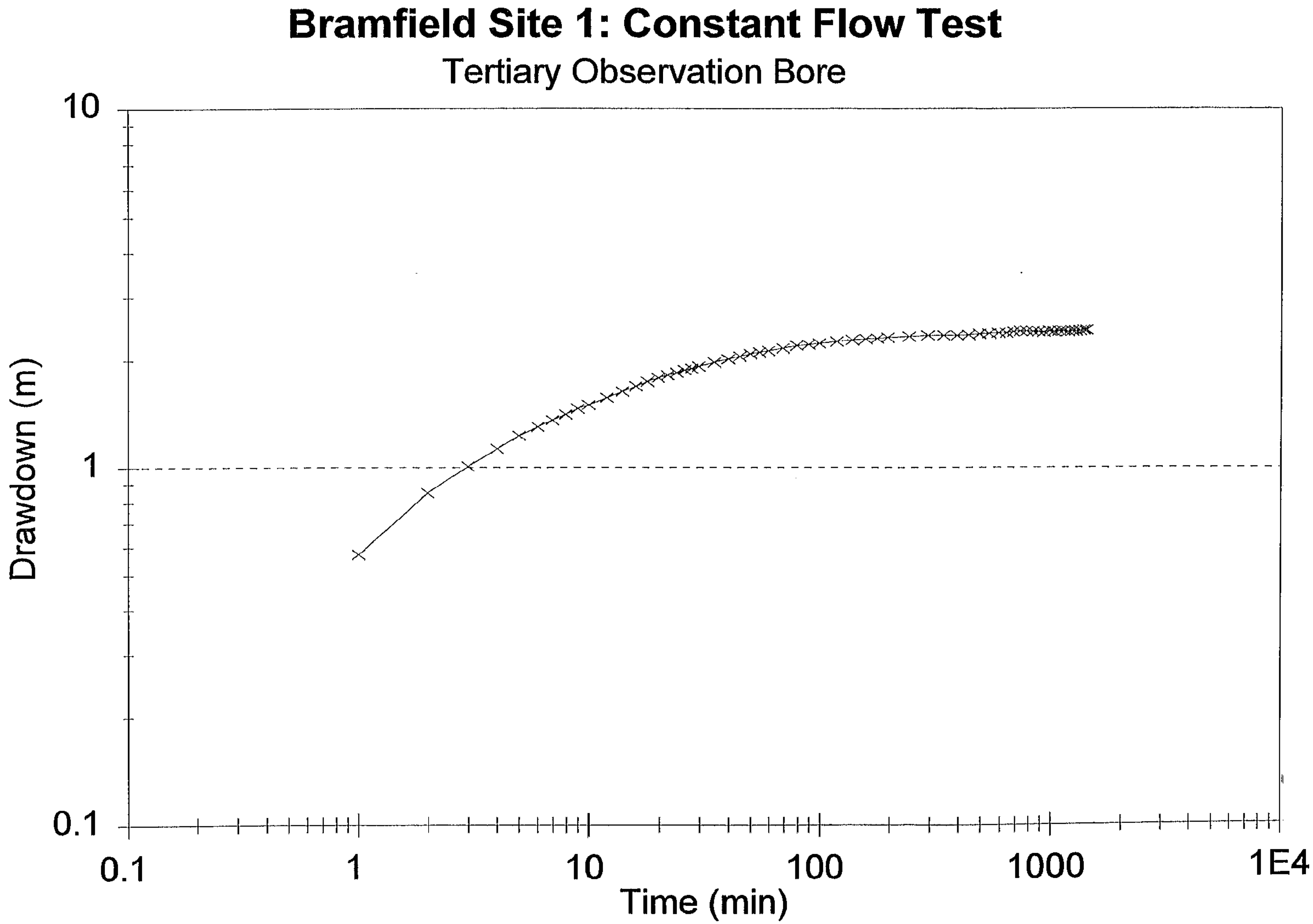


Figure B4: Log/Log Plot of Drawdown Vs Time for Constant Flow Test - TAA 60

Stage Test

Pumped Bore: TAA 63
Interval Tested: From: 32.0 m To: 35.0 m
SWL at Start: 12.80 m

Hole Depth: 35.0 m
Depth of Pump: 31.0 m

STEP	Q (m^3/min)	$s_t=1$	$s_{t=1}$/Q	$s_t=10$	$s_{t=10}$/Q	$s_t=100$	$s_{t=100}$/Q	Δs	Δs/Q	T *
1	0.12	1.80	15.00	2.05	17.08	2.30	19.17	0.25	2.08	126.5
2	0.24	3.70	15.42	4.25	17.71	4.80	20.00	0.55	2.29	115.0
3	0.36	5.40	15.00	6.20	17.22	7.00	19.44	0.80	2.22	118.6

* $T = \frac{0.183\,Q}{\Delta s}$ - Jacob Equation

Well Equation: $s = aQ + cQ^2 + bQ\log_{10}t$
From s_t/Q Vs Q:

$a = 14.6$
$b = 2.2$
$c = 2.5$

Therefore: $s = 14.6Q + 2.5Q^2 + 2.2Q\log_{10}t$

Main Test (Constant Flow Test)

Semi-Log Plot

$$T = \frac{0.183 \times Q}{\Delta s}$$

Q = 518.40 m^3/day
Δs = 0.80m pumping
Δs = 0.84m recovery

Therefore: During pumping $T = \frac{0.183 \times 518.4\ m^3/day}{0.80m}$ = 118.58 m^3/day/m

During recovery $T = \frac{0.183 \times 518.4\ m^3/day}{0.84m}$ = 112.94 m^3/day/m

Observation Bore - TAA 60

Δs = 0.85m observation bore

Therefore $T = \frac{0.183 \times 518.4\ m^3/day}{0.85m}$ = 111.61 m^3/day/m

Log-Log Plot

Transmissivity (T)

$$T = \frac{Q\,w(u,\ r/B)}{4\Pi s}$$

$Q = 518.40\ m^3/day$
$s = 0.45$
$w(u,\ r/B) = 1$

Therefore: $$T = \frac{518.40\ m^3/day \times 1}{4 \times \Pi \times 0.45} = \underline{\underline{91.67\ \ m^3/day/m}}$$

Storativity (S)

$$S = \frac{4\ T\ u\ t}{r2}$$

$T = 91.67\ \ m^3/day/m$
$r = 17.8\ m$
$u = 0.1$
$t = 1.46 \times 10^{-3}$ day

Therefore: $$S = \frac{4 \times 91.67\ \ m^3/day/m \times 0.1}{(17.8m)^2} = \underline{\underline{1.69 \times 10^{-4}}}$$

Permeability of Aquitard (P')

$$P' = \frac{Tm'(r/B)^2}{r^2}$$

m' = saturated thickness of aquitard ~ 8.0 m
$T = 91.67\ \ m^3/day/m$
$r = 17.8$
$r/B = 0.075$

Therefore: $$P' = \frac{91.67\ \ m^3/day/m \times 8.0\ m \times (0.075)^2}{(17.8m)^2} = 2.3 \times 10^{-2}\ m/day$$

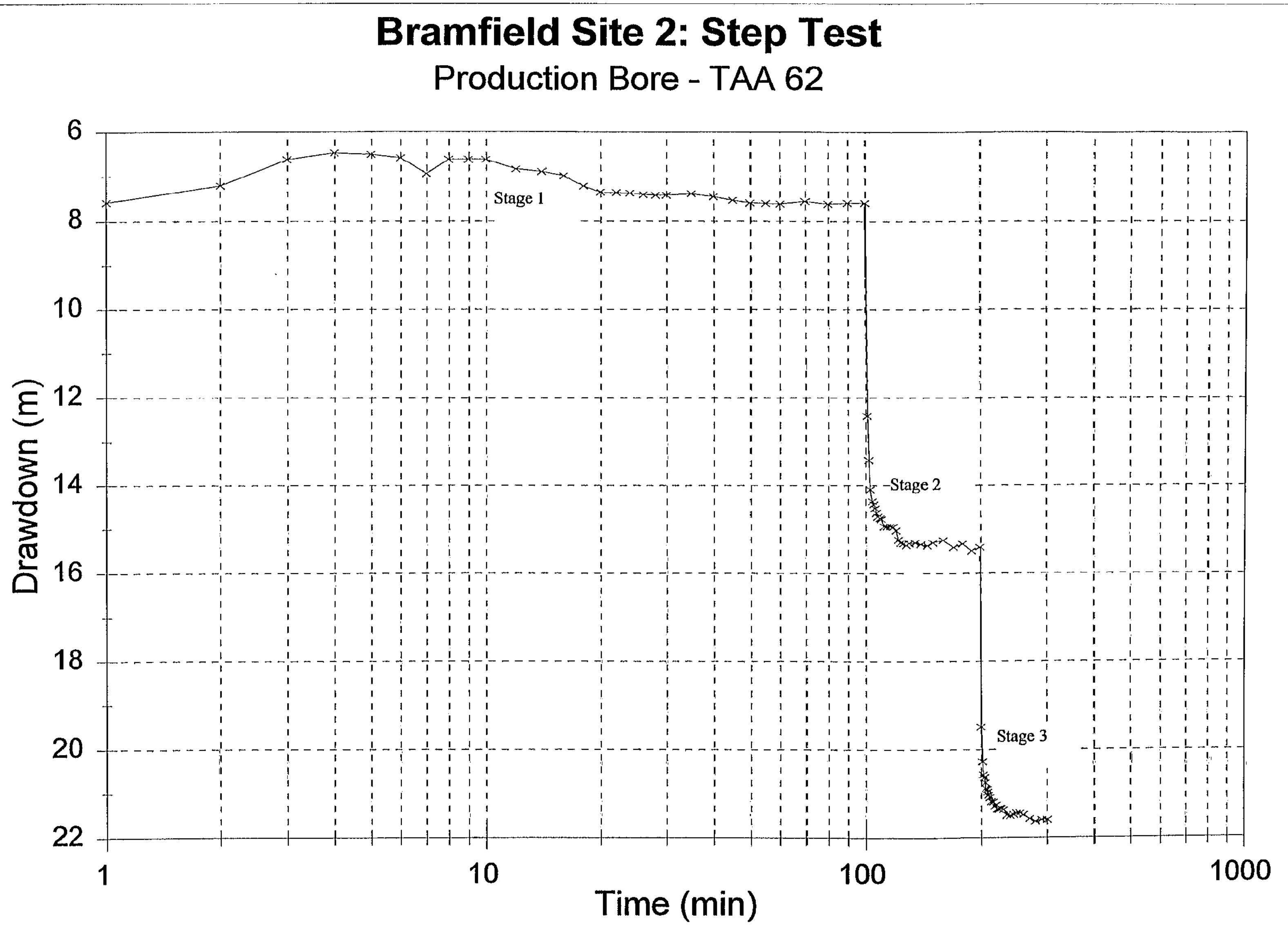


Figure B5: Drawdown Vs Time for step test - TAA 62

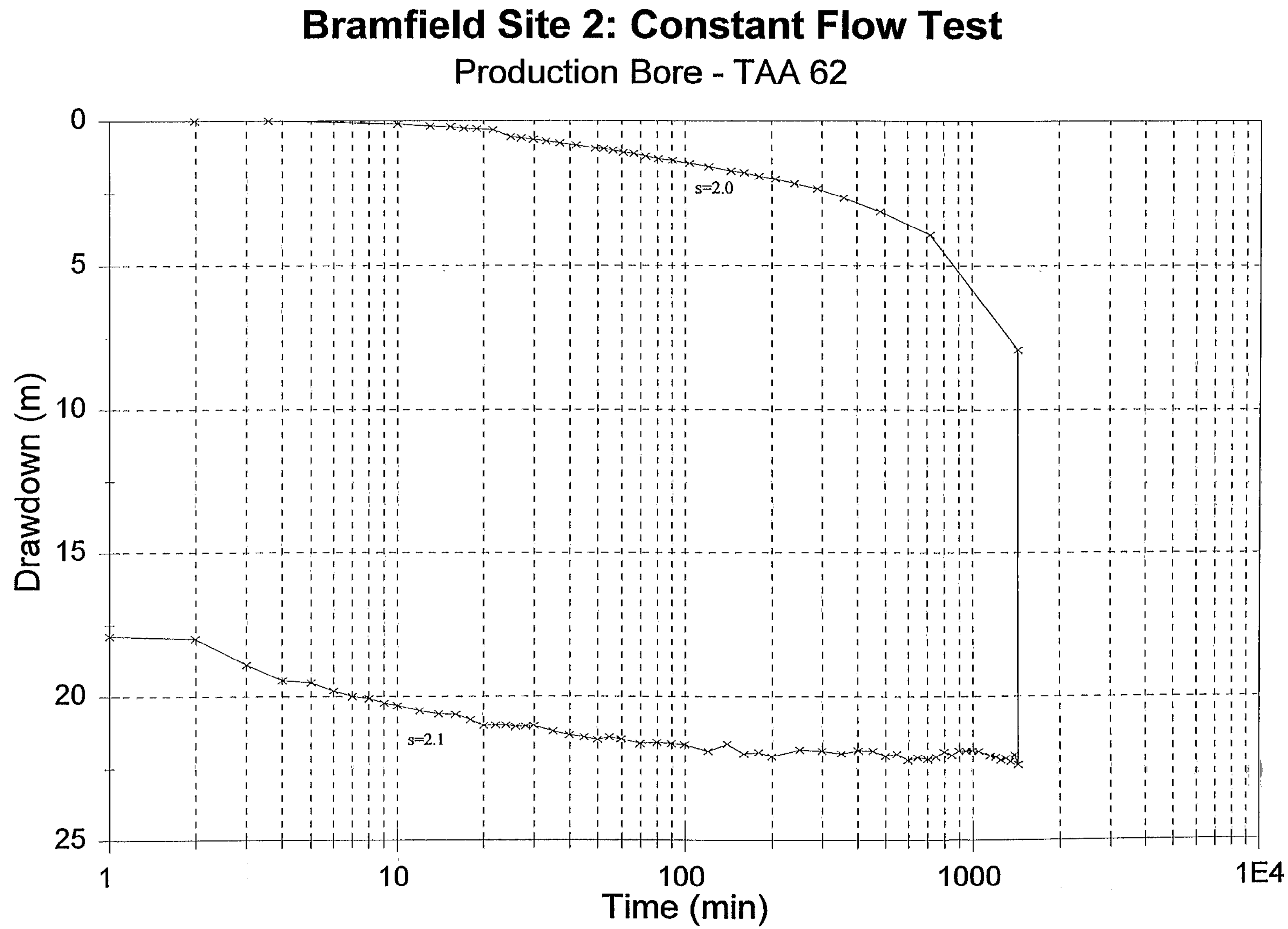


Figure B6: Drawdown Vs Time for Constant Flow Test - TAA 62

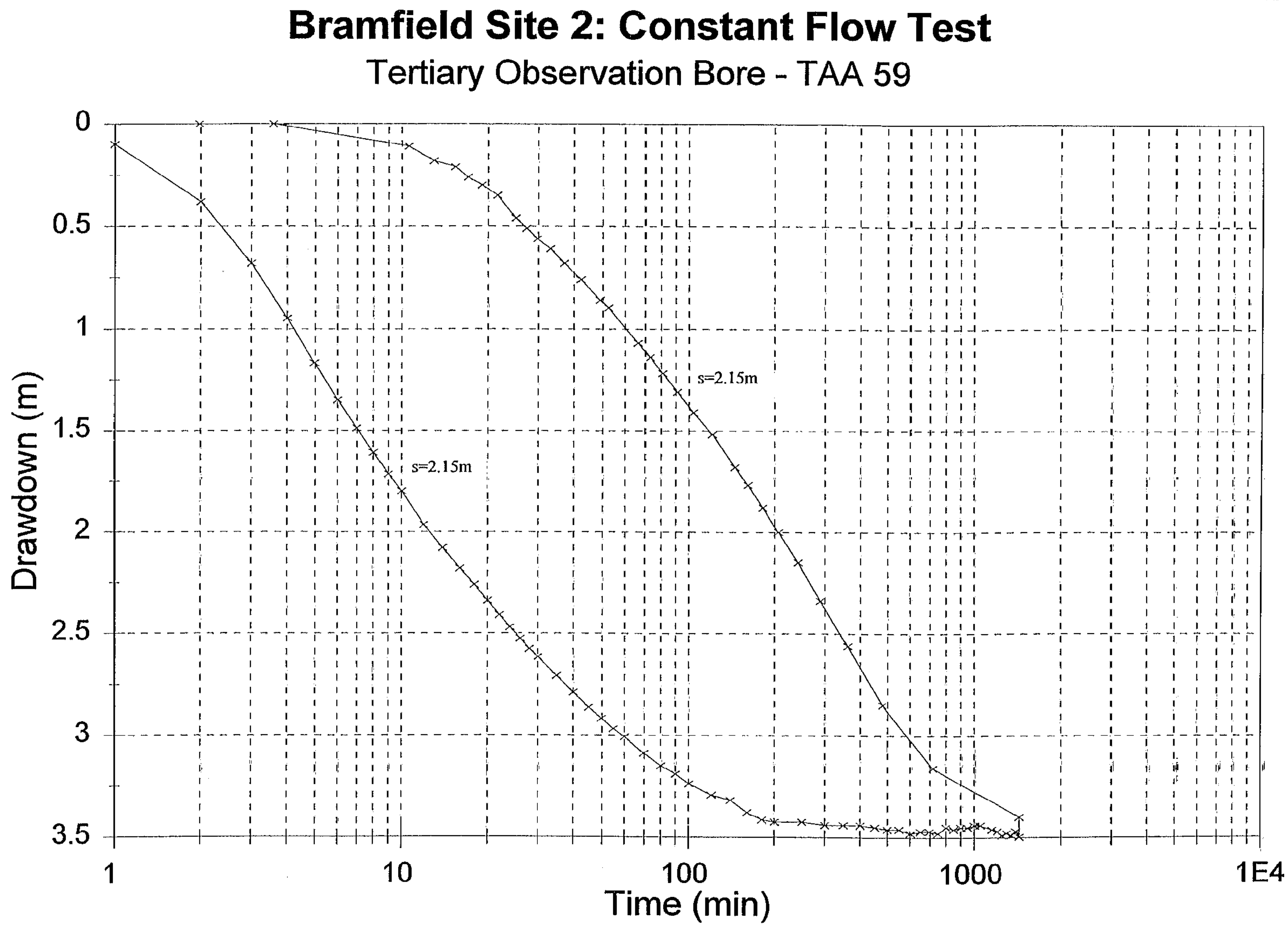


Figure B7: Drawdown Vs Time for Constant Flow Test - TAA 59

Stage Test

Bore Number: TAA 62
Interval Tested: From: 32.0 m To: 35.0 m
SWL at Start: 4.5

Hole Depth: 35.0 m
Depth of Pump: 31.0 m

STEP	Q (m^3/min)	st =1	st = 1 / Q	st = 10	st =10 / Q	st =100	st=100 / Q	Δs	Δs / Q	T *
1	0.06	6.15	102.5	6.85	114.7	7.55	125.8	0.7	11.67	22.6
2	0.12	12.6	105	15.15	117.9	15.7	130.8	1.55	12.92	20.4
3	0.168	16.5	98.2	18.6	110.7	20.7	123.2	2.1	12.5	21.1

* $T = \frac{0.183\ Q}{\Delta s}$ - Jacob Equation

Well Equation: $s = aQ + cQ^2 + bQ\log_{10}t$
From st/Q Vs Q:

a = 98.8
b = 12.4
c = 59

Therefore: $s = 98.8Q + 59Q^2 + 12.4\log_{10}t$

Main Test (Constant Flow Test)

Semi-Log Plot

Transmissivity (T)

$T = \frac{0.183 \times Q}{\Delta s}$

Q = 241.92 m^3/day
Δs = 2.1m pumping
Δs = 2.0m recovery

Therefore: During pumping $T = \frac{0.183 \times 241.92\ m^3/day}{2.1\ m}$ = 21.1 m^3/day/m

During recovery $T = \frac{0.183 \times 241.92\ m^3/day}{2.0\ m}$ = 22.1 m^3/day/m

Observation Bore - TAA 59

Δs = 2.15 m observation bore

Therefore $T = \frac{0.183 \times 241.92\ m^3/day}{2.15\ m}$ = 20.6 m^3/day/m

Storativity (S)

$$S = \frac{2.25 \times T \times t_0}{r^2}$$

$T = 20.59\ m^3/day/m$
$t_0 = 1.01 \times 10^{-3}$ days
$r = 15.8$ m

Therefore: $S = \frac{2.25 \times 20.59\ m^3/day/m \times 1.01 \times 10^{-3}\ day}{(15.8m)^2} = \underline{\underline{1.9 \times 10^{-4}}}$

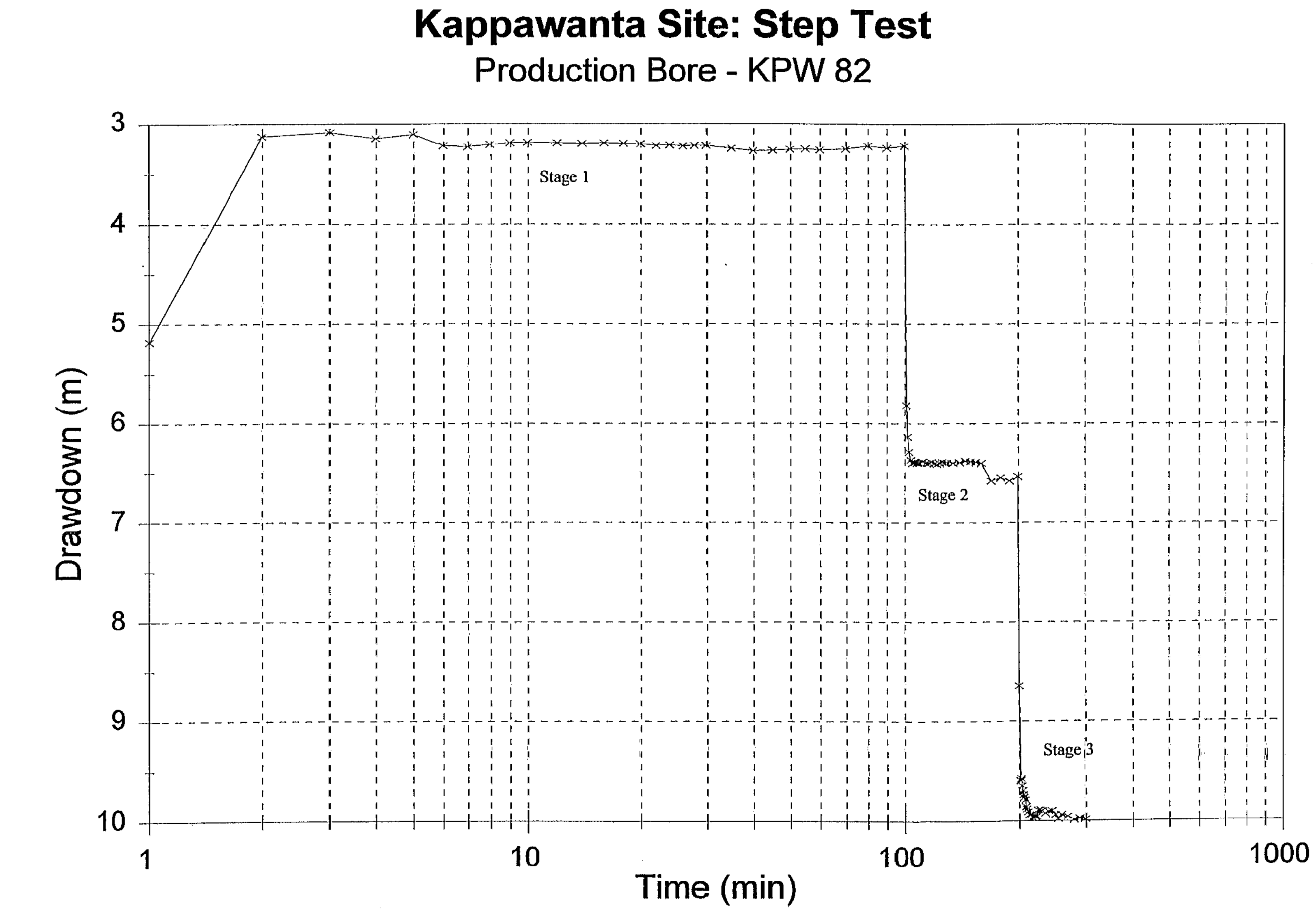


Figure B8: Drawdown Vs Time for Step Test - KPW 82

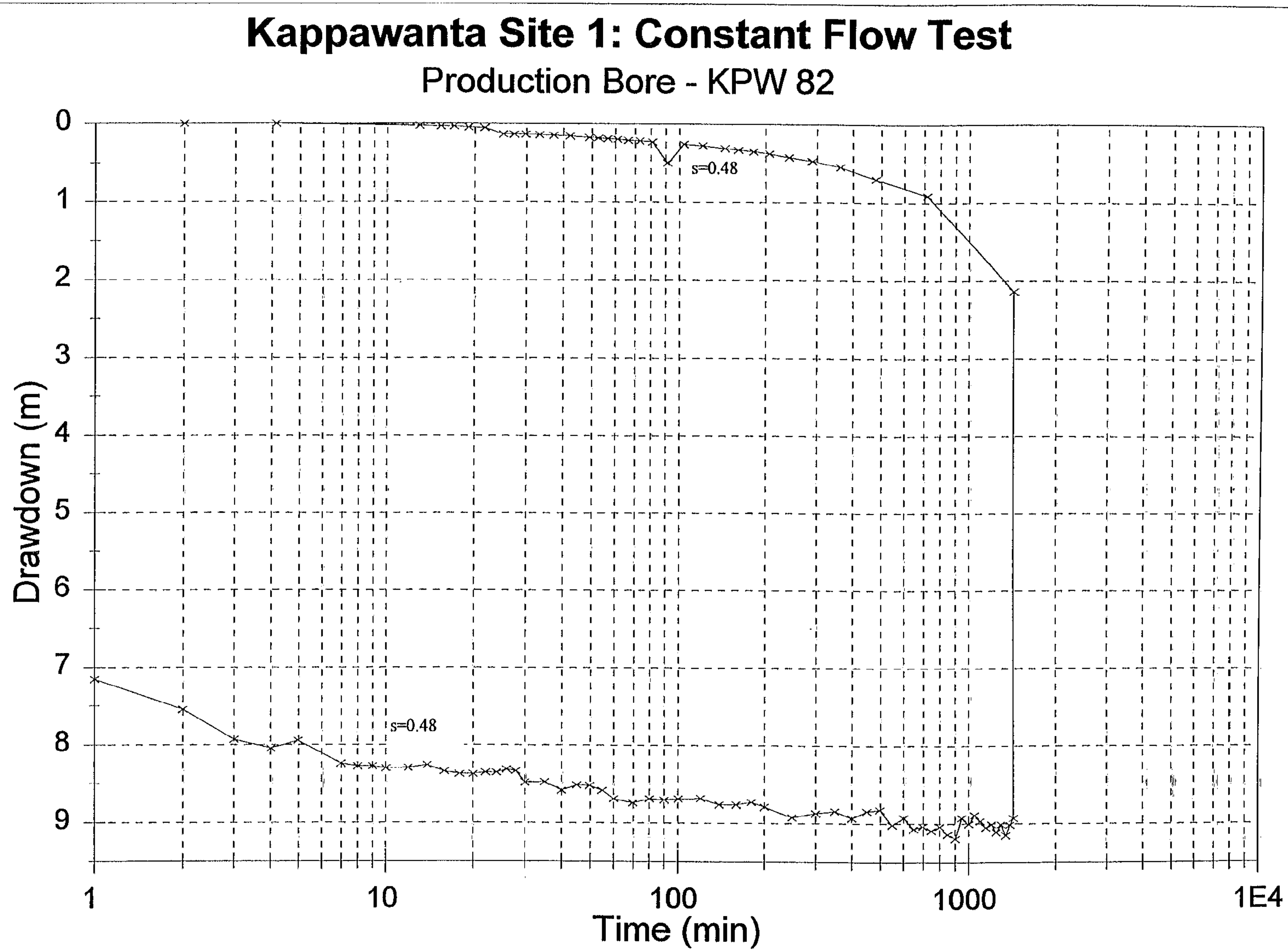


Figure B9: Drawdown Vs Time for Constant Flow Test - KPW 82

Stage Test

Bore Number: KPW 82
Interval Tested: From: 19.7 m To: 22.7 m
SWL at Start: 6.42 m

Hole Depth: 22.7 m
Depth of Pump: 18.5 m

STEP	Q (m^3/min)	$s_t = 1$	$\frac{s_t = 1}{Q}$	$s_t = 10$	$\frac{s_t = 10}{Q}$	$s_t = 100$	$\frac{s_t = 100}{Q}$	Δs	$\frac{\Delta s}{Q}$	T *
1	0.036	2.98	82.8	3.16	87.8	3.34	92.8	0.18	5	52.7
2	0.072	5.8	80.6	6.15	85.4	6.5	90.3	0.35	4.86	54.2
3	0.108	8.77	81.2	9.3	86.1	9.83	91.0	0.53	4.91	53.7

$* \; T = \frac{0.183\,Q}{\Delta s}$ - Jacob Equation

Well Equation: $\Delta s = aQ + cQ^2 + bQ\log_{10}t$
From s_t/Q Vs Q:

$a = 79.1$
$b = 4.9$
$c = 20$

Therefore: $\Delta s = 79.1Q + 20Q^2 + 4.9Q\log_{10}t$

Main Test (Constant Flow Test)

Semi-Log Plot

$T = \frac{0.183 \times Q}{\Delta s}$

$Q = 138.24 \; m^3/day$
$\Delta s = 0.48 \; m$

Therefore: $T = \frac{0.183 \times 138.24 \; m^3/day}{0.48 \; m} = \underline{52.70 \; m^3/day/m}$

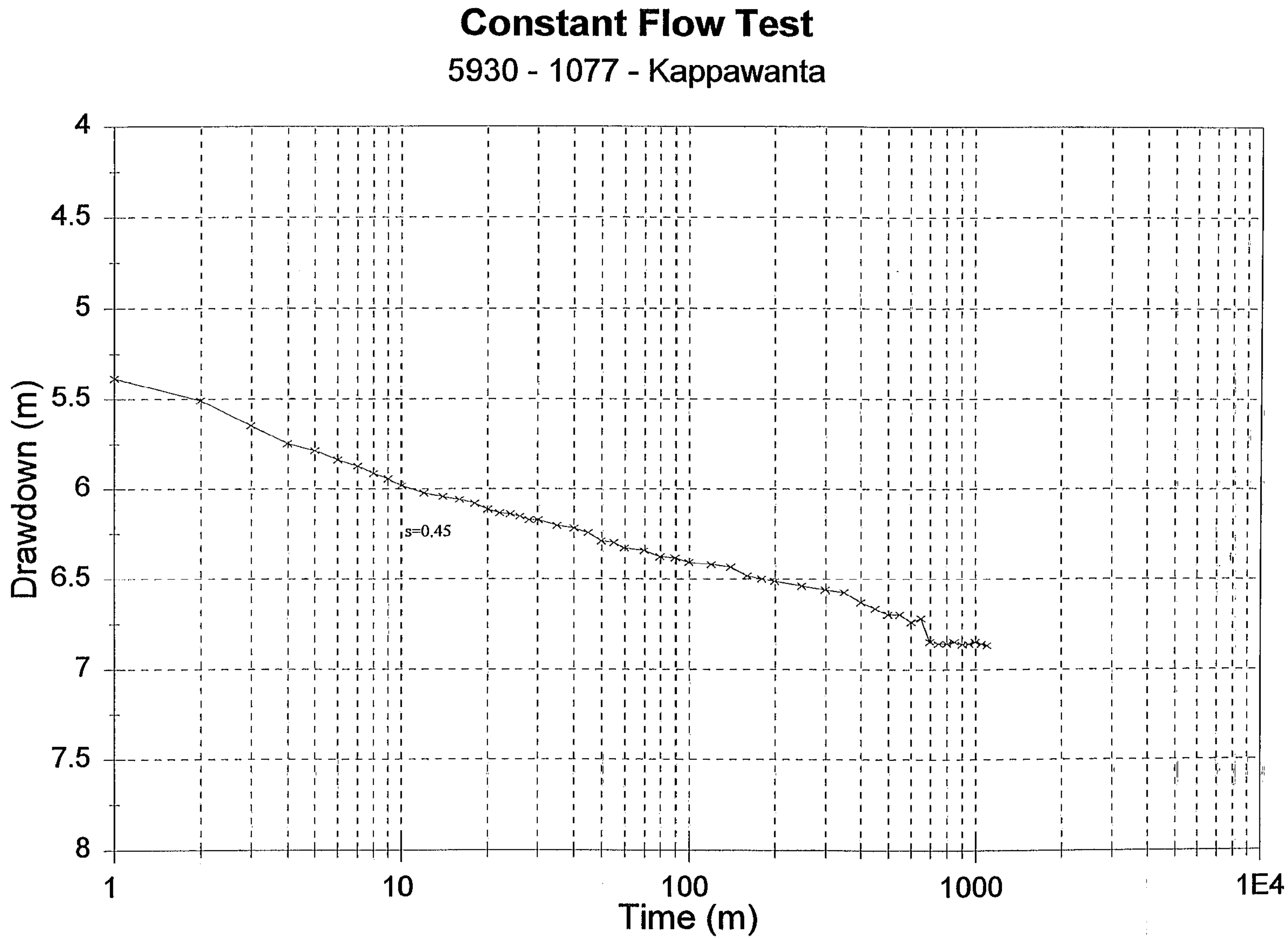


Figure B10: Drawdown Vs Time for Constant Flow Test - PN 95802

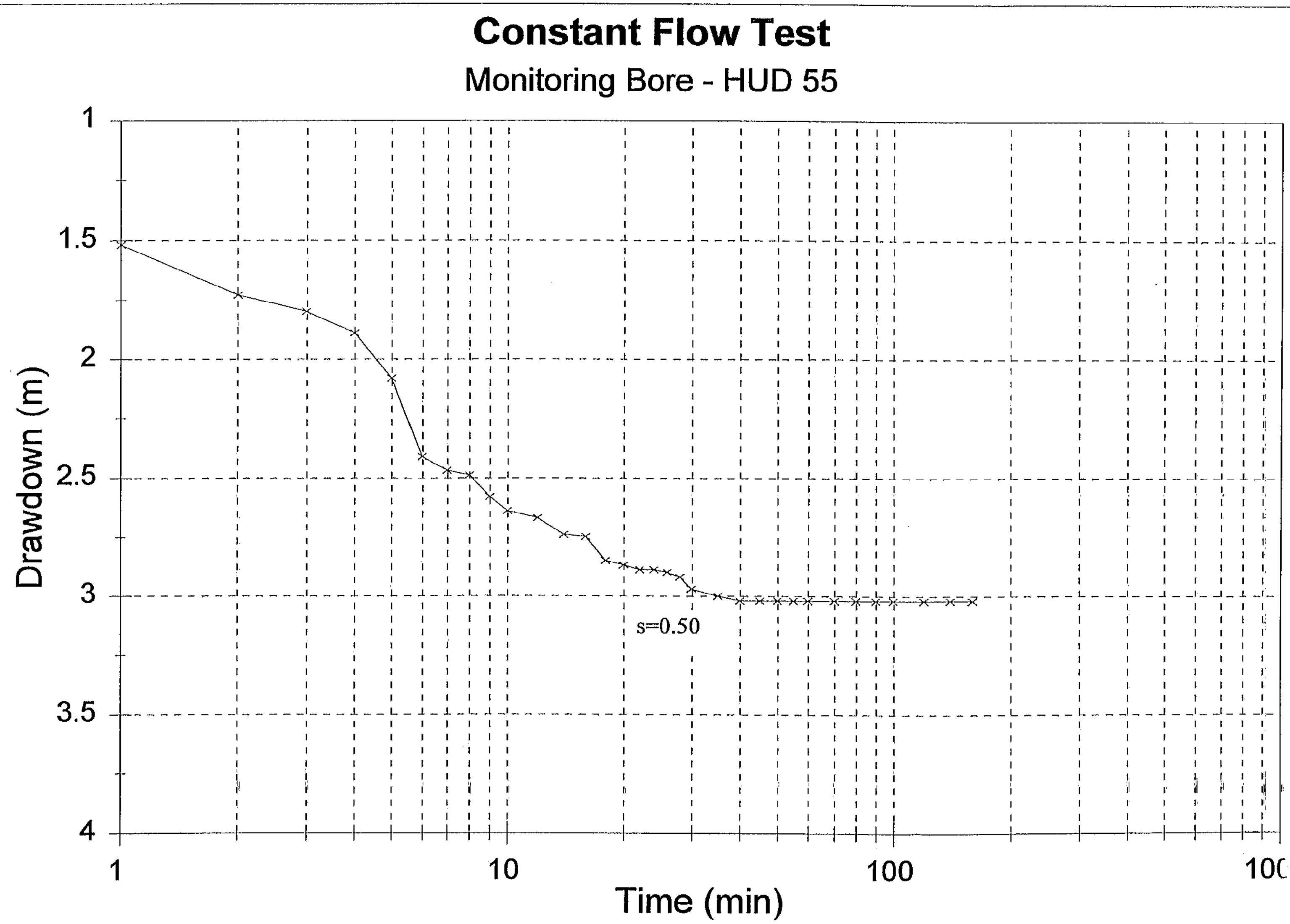


Figure B11: Drawdown Vs Time for Constant Flow Test - Hud 55

Main Test (Constant Flow Test)

Pumped Bore: HUD 55
Interval Tested: From: 15.0 m To: 18.0 m
SWL at Start: 12.85 m

Hole Depth: 18.0 m
Depth of Pump: Unknown

Semi-Log Plot

$$T = \frac{0.183 \times Q}{\Delta s}$$

$Q = 17.3\ m^3/day$
$\Delta s = 0.50\ m$

Therefore $$T = \frac{0.183 \times 17.3\ m^3/day}{0.50\ m} = \underline{6.33\ m^3/day/m}$$

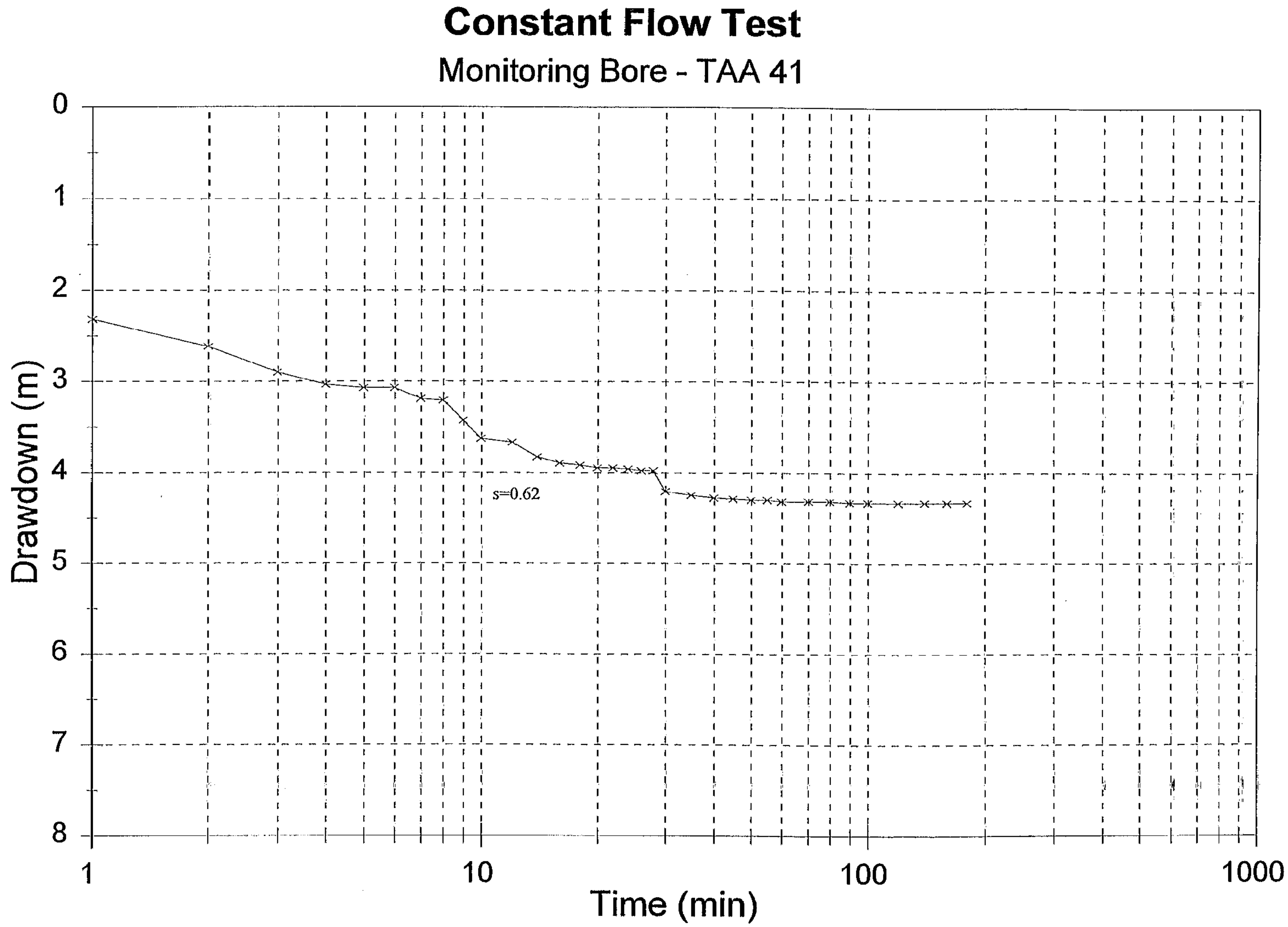


Figure B12: Drawdown Vs Time for Constant Flow Test - TAA 41

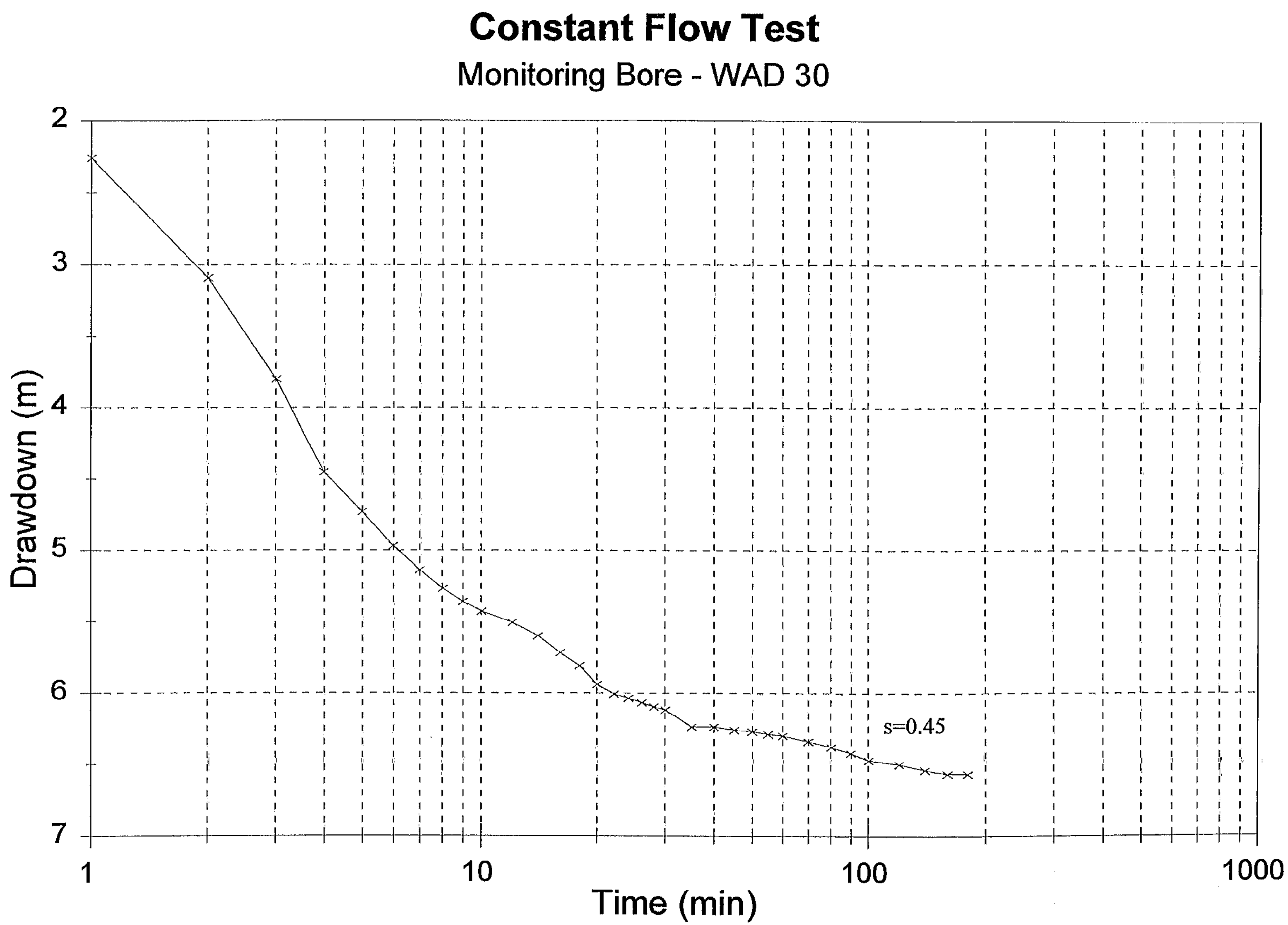


Figure B13: Drawdown Vs Time for Constant Discharge Test - WAD 30